5.0 Marsh Readiness and Ionic Conditioning

One of the defining aspects of MWTS project is in evaluating the role of the wetland system in ameliorating the changes to the chemical signature of the water effected by chemical treatment. The concern is whether chemically treated waters are "marsh ready," that is, of acceptable quality to be discharged to the marshes of the Everglades ecosystem.

5.1 Methods

There are several existing graphical methods for characterizing the chemistry of waters. Several of these approaches focus on ionic constituents, specifically anions and cations. The approaches include comparisons by stacked bar charts for anions and cations, pattern diagrams (e.g., Stiff diagrams) developed for oilfield drilling, log diagrams (Schoeller plots), radial charts, and trilinear plots.

The ionic parameters being evaluated in this project are alkalinity, aluminum, chloride, sulfate, bicarbonate, calcium, magnesium, and iron. The concentration of each of these parameters was converted to a milliequivalent per liter value. Masses, absolute values of the ion charge assumed for the constituents, and conversion factors are shown in Exhibit 5-1. For alkalinity to be represented, it was necessary to determine the predominant form of carbonate. The pH range in the MWTS treatment cells is 7-8. Between pH ranges of 7 to 9, bicarbonate predominates, accounting for 80-95 percent of the total alkalinity (Wetzel, 1983). For the purposes of plotting in meq/L, bicarbonate was used as a surrogate for alkalinity.

For comparison, radial and Schoeller plots were selected. In a radial plot, ion concentrations, expressed in meg/L, are plotted in counter-clockwise order. Waters with comparable water quality will form similar shapes from connecting the resulting points (Todd, 1980).

EXHIBIT 5-1
Calculation Data for Conversion of Concentration Data (mg/L) to Milliequivalents Per Liter (meq/L)

Constituent	Atomic Weight	Ion Charge	Conversion factor (divisor)
Chloride (Cl^-)	35.453	1	35.453
Sulfate (SO_4^{-2})	96.056	2	48.028
Aluminum (Al^{+3})	26.982	3	8.994
Bicarbonate (HCO_3^-)	61.016	1	61.016
Magnesium (Mg^{+2})	24.305	2	12.153
Calcium (Ca^{+2})	40.080	2	20.040
Iron (Fe^{+3})	55.847	3	18.616

In Schoeller plots, ion concentrations, in meg/L per liter, are plotted on a logarithmic scale. The points generated are then joined by straight lines. If the line connecting two points in one sample is parallel to the same line from a different sample, then the ratio of ions in both water samples is equal (Todd, 1980). It should be noted that aluminum and iron are expressed in microequivalents per liter on all Schoeller plots.

Both of these graphical methods are used to display and compare water quality results. The radial plots create shapes that can be used to compare water quality between different samples. However, it is easier to detect water quality deviations among a group of other samples using the Schoeller plots. This is because Schoeller plots show both the absolute value of each chemical parameter and the concentration differences between samples (Todd, 1980).

Another way to establish trends within a cell is to determine if and where any significant differences in concentrations exist between stations in the treatment cells. Multiple means comparisons were performed using the Tukey–Kramer Multiple Comparison Method (Kramer, 1956) where all possible comparisons between stations within a cell were tested simultaneously. The method accounts for the unequal sample sizes of the various stations within each cell (the 2/3 station in each cell contained only four observations compared to 13 for the other stations). Within the multiple comparison method this fact influences the estimated variance of each mean when using this statistic, so that the test provides the same level of confidence for all comparisons, regardless of sample size. Thus, in presenting results comparing the different stations within a cell, *the standard error for each station mean is that produced by the test statistic, and may not be that produced by making the same calculation on only the data from a particular station*. The mean errors bars shown for NTC or STC inflow stations for a parameter will be different, in spite of the fact that the inflow data are the same for the NTC cells, and also for the STC cells (all inflow values are provided by a single sample taken immediately before the source water was split between cells).

5.2 Results

Several different combinations of data were plotted to evaluate different aspects of ionic conditioning. For each cell, data from the inflow, one-third, and outflow stations were plotted using both of the methods described above for the calibration period (Exhibits 5-3 to 5-12, September 1998 through January 2000), and for the treatment period (Exhibits 5-13 to 5-22, March 2000 through December 2000). This was done in an attempt to show any concentration changes between stations. To compare outflow concentrations between cells, outflow for each cell was plotted with inflow concentrations for the calibration period (Exhibits 5-23 to 5-26), and for the treatment period (Exhibits 5-27 to 5-30). Inflow for each cell was also plotted with plant effluent to establish which of the treatments are having more of an effect on concentrations (Exhibits 5-31 to 5-34). Lastly, calibration period inflow and outflow was plotted with treatment period inflow and outflow to show if patterns seen during treatment are already characteristic of the cells (Exhibits 5-35 to 5-46). Each of these plots provides a different way to examine and compare changes in ionic parameters.

For the treatment period only, the mean concentrations of ions, and test generated standard errors bars associated with them, were plotted for each cell (Exhibits 5-47 to 5-74).
To determine a significant difference, each plot was evaluated to determine if standard error bars were overlapping. If they were not, then it was assumed that those stations were not significantly different from one another. TDS, total organic carbon (TOC), pH, TP, TDP, SRP, and total kjeldahl nitrogen (TKN) were included in this analysis. Results are provided

as a table describing the stations in each cell that had significantly different parameter mean values in the treatment period (Exhibit 5-2).

EXHIBIT 5-2
Summary of Significant Differences Between Stations by Multiple Means Comparison for Treatment Period April through December, 2000

	Cell 2	Cell 3	Cell 4	Cell 6	Cell 7
Alkalinity	PlantEff < All	Inflow < stn_2/3	PlantEff < stn_1/3	All < stn_2/3	PlantEff < All
Aluminum	All < stn_1/3	All < stn_1/3	All < stn_1/3	All < stn_2/3	--
Calcium	Inflow>PlantEff Inflow>stn_1/3 Inflow >Outflow	--	PlantEff < stn_1/3 stn_1/3 > Ouflow	PlantEff > stn_1/3 PlantEff > Outflow	--
Chloride	PlantEff > All Inflow < stn_1/3 Inflow < Outflow	stn_2/3 > stn_1/3 stn 2/3 > Outflow	PlantEff > All	--	PlantEff > All
Iron	PlantEff > All	--	stn_1/3 > Inflow stn_1/3 > PlantEff stn_1/3 > Outflow	stn_2/3 > Inflow stn_2/3 > Outflow	stn_1/3 > Inflow stn_1/3 > PlantEff stn_1/3 > Outflow
Magnesium	stn_2/3 > PlntEff stn 2/3 > Outflow	stn 2/3 > Outflow	--	stn_2/3 > All	stn 2/3 > Outflow
Sulfate	--	--	--	--	--
TDS	Inflow < All	stn 2/3 > All	PlantEff > stn_1/3 PlantEff > Outflow stn_2/3 > stn_1/3 stn_2/3 > Outflow	--	PlantEff > Outflow
TOC	Inflow > stn_1/3 Inflow > Outflow stn_2/3 > Outflow	--	stn_1/3 > Outflow	--	stn_1/3 > Outflow
pH	Inflow < All PlntEff <All except Inflow	Inflow < All	Inflow < All Stn_2/3 < All except Inflow	Stn_1/3 < All Outflow < Inflow	PlntEff < All except Outflow Outflow < All excpet PlntEff
TP	Inflow > All PlntEff > All except Inflow	Stn_1/3 > All Inflow > stn_2/3 Inflow > Outflow	Stn_1/3 > All	Stn_1/3 > Inflow Stn_1/3 > Outflow	Stn_1/3 > All
TDP	Inflow > All	Stn_1/3 > All	Inflow > All	--	--
SRP	Inflow > All	Inflow > stn_2/3 Inflow > Outflow stn1/3 > stn_2/3 stn_1/3 > Outflow	Inflow > All	--	PlntEff > stn_1/3 PlntEff > Outflow
TKN	Infllow > All except PlntEff PlntEff > All except Inflow	Inflow > stn_2/3 Inflow > Outflow stn_1/3 > stn_2/3 stn_1/3 > Outflow	Stn_1/3 > All	--	Stn_1/3 > All

5.2.1 Calibration Period

For NTC-FeCl and NTC-PACL, iron and aluminum concentrations were the highest at the one-third station. Otherwise, there was little difference in concentrations of ionic parameters between sampling stations at the NTCs (Exhibit 5-3 to 5-8). During the calibration period, outflow concentrations for most parameters at the NTCs behaved in a similar manner. The exception to this was the outflow aluminum concentration in NTC-Control, which was higher than the inflow for the NTCs (Exhibits 5-23 and 5-24).

STC-Control had chloride, calcium, bicarbonate, and magnesium concentrations reaching a maximum at the one-third station (Exhibits 5-9 and 5-10). Excluding iron and aluminum, STC-PACL showed little differences in ion concentrations between stations (Exhibits 5-11 and 5-12). During the calibration period, iron and aluminum were being exported from STC-Control and STC-PACL, as the outflow values exceeded the inflow (Exhibits 5-9, 5-10, 5-11, 5-12, 5-25, 5-26, 5-41, 5-42, 5-43, and 5-44).

5.2.2 Treatment Period

5.2.2.1 Alkalinity/Bicarbonate

Radial and Schoeller plots show little differences between stations in bicarbonate concentrations (Exhibits 5-13 to 5-21). For NTC-FeCL, NTC-PACL, and STC-PACL, outflow from the treatment plant had the lowest concentrations. Trends within the cell are easier to detect by reviewing the standard error plots (Exhibits 5-2, 5-47, and 5-48). All treatments lowered bicarbonate concentrations to around 200 mg/L. This was expected to drop since chemical coagulants react with water to form insoluble hydroxide precipitates (Sawyer, McCarty, and Parkin, 1994). Between the plant effluent and the one-third station, concentrations became significantly higher, indicating that the marsh is stabilizing alkalinity concentrations in the water column (Exhibits 5-31 to 5-34). By the time water reached the outflow, concentrations were similar to the inflow (Exhibits 5-27 to 5-30).

5.2.2.2 Aluminum

Previous research indicated that dissolved aluminum concentrations usually decrease when passing through wetlands (Kadlec and Knight, 1996). An interesting phenomena regarding aluminum occurred in NTC-FeCl and NTC-PACL. While concentrations in the plant effluent were higher than the inflow (Exhibits 5-31 and 5-32), aluminum levels were actually higher at the one-third station than the plant effluent (Exhibits 5-16 and 5-17). While this corresponds to the calibration period and control cell data (Exhibits 5-15 and 5-16), which also showed an increase in aluminum at the one-third station, this phenomenon could also be explained by problems in sample collection. In the case of NTC-PACL, several samples collected at the one-third station contained aluminum floc from the plant outflow (Exhibits 5-4 and 5-8). Aluminum concentrations dropped through NTC-PACL; however; changes in aluminum concentrations did not follow this pattern in NTC-FeCl and NTC-Control. Schoeller plots indicated that all the NTCs outflow aluminum concentrations were higher than the inflow (Exhibit 5-28), but a significant difference was not shown in the standard error plots between the outflow and inflow values (Exhibits 5-2 and 5-49).

Aluminum levels in STC-PACL were elevated greatly by treatment (Exhibits 5-27, 5-28, 5-33, and 5-34). Concentrations dropped significantly as water flowed through the marsh (Exhibits 5-2, 5-21, and 5-50). Outflow concentrations for STC-PACL appeared to be greater than inflow values; however, this was not found to be statistically significant (Exhibits 5-2, 5-30, and 5-50).

5.2.2.3 Calcium

Surface waters typically contain an excess of calcium; therefore, concentrations in wetlands are not likely to change (Kadlec and Knight, 1996). Review of Radial and Schoeller plots showed almost no detectable changes in calcium concentrations between stations (Exhibits 5-14 to 5-22, and 5-27 to 5-34). Standard error plots revealed that iron treatment (NTC-FeCL) caused a significant drop in calcium due to precipitation reactions, but aluminum treatment (NTC-PACL, STC-PACL) does not significantly affect calcium concentrations (Exhibits 5-2, 5-51, and 5-52).

5.2.2.4 Chloride

Radial and Schoeller plots showed detectable changes in chloride concentrations of the treatment cells in the plant effluent (Exhibits 5-2, 5-14 to 5-22, and 5-27 to 5-34). Exhibits 5-53 and 5-54 also showed a significant increase in chloride concentration from the inflow to the plant outflow. This increase can be explained by the use of Ferric Chloride and polyaluminum chloride as treatment agents. Once water reached the one-third station, chloride concentrations seemed to stabilize, indicating that the marsh was having little effect on the concentrations. This result is unsurprising, as chloride is highly soluble and biological demand for chloride is low (Kadlec and Knight, 1996). Outflow concentrations of chlorides in NTC-FeCL were significantly higher than inflow values (Exhibits 5-2, 5-28, and 5-53).

5.2.2.5 Iron

NTC-FeCL iron concentrations were at a maximum in the plant outflow and then dropped as water traveled through the marsh (Exhibits 5-14 and 5-55). While concentrations of iron were elevated in the plant outflow of NTC-PACL and STC-PACL, the one-third station was significantly higher than the plant outflow (Exhibits 5-2, 5-55, and 5-56). As in the calibration period (Exhibits 5-8 and 5-12), it appeared that NTC-PACL and STC-PACL were exporting iron near the one-third station during the treatment period (Exhibits 5-18, 5-19, 5-20, and 5-21). This was also true of the control cells, where the one-third concentrations exceeded the inflow values (Exhibits 5-16 and 5-20). With the exception of NTC-FeCL, iron concentrations in the outflow were lower than the inflows (Exhibit 5-28).

5.2.2.6 Magnesium

Surface water magnesium concentrations almost always exceed biological requirements; therefore, concentrations in wetlands are not likely to change significantly (Kadlec and Knight, 1996). Review of Radial and Schoeller plots showed almost little detectable change in magnesium concentrations between stations (Exhibits 5-14 to 5-22 and 5-27 to 5-34). Standard error plots confirmed these results in both the control and treatment cells (Exhibit 5-2, 5-57, and 5-58).

5.2.2.7 Sulfate

Review of Radial and Schoeller plots showed almost no detectable changes in sulfate concentrations between stations (Exhibits 5-14 to 5-22, and 5-27 to 5-34). Standard error plots confirmed these results (Exhibits 5-59 and 5-60).

For comparison, the Loxahatchee National Wildlife refuge (WCA 1) (1996-1998), Water Conservation Area 2A (WCA-2A) (1996-1998), and Conservation area 3A (WCA-3A) (1977-1983) (SFWMD, 2000; Swift and Nichols, 1987) were plotted using the same methods (Exhibits 5-44 and 5-45). Comparing test cell data with data from the WCAs was a useful method of extending the comparison to consider the question of overall "marsh readiness" of the water. The three plots comparing the WCAs showed that constituent concentrations differed between the respective conservation areas. The Schoeller plot (Exhibit 5-45), however, indicated that ratios of ions were similar for WCA 1 and WCA 2. Comparison of the MWTS test cells treatment period data with WCA data suggested that the ionic condition of a test cell's outflow was similar to that found in the interior of WCA 2. The exception was NTC-FeCL, the iron treatment cell.

5.2.2.8 Other Parameters

Total Dissolved Solids. TDS concentrations in NTC-FeCL significantly increased between the inflow and plant outflow due to treatment (Exhibit 5-2). Although significant differences existed between sites within a cell, there did not seem to be a particular pattern in any of the cells as water flows through the marsh, except for STC-PACL. This cell showed a slight trend of decreasing concentrations (Exhibits 5-2, 5-61, and 5-62).

Total Organic Carbon. There was a general trend of decreasing TOC concentrations through NTC-FeCL and STC-PACL; otherwise, marsh conditioning did not appear to affect TOC concentrations (Exhibits 5-2, 5-63, and 5-64).

pH. In the NTCs, pH levels increased significantly in the plant outflow (Exhibits 5-2, 5-65, and 5-66). The opposite was true in STC-PACL. Ferric chloride dosing (NTC-FeCL) required the addition of sodium hydroxide to maintain pH in a specified range. With the exception of STC-FeCL, pH levels rose from the beginning of the cell to the one-third station (Exhibits 5-2, 5-65, and 5-66). pH levels stabilized after the one-third station in the NTCs, but they decreased slightly at the STCs (Exhibits 5-65 and 5-66).

Total Phosphorus. TP concentrations in NTC-FeCL dropped significantly between the plant outflow and the one-third station, after which the concentrations stabilized (Exhibits 5-2 and 5-67). Concentrations at the one-third station in NTC-Control, NTC-PACL, STC-Control, and STC-PACL were significantly higher than either the inflow (for NTC-Control and STC-Control) or the plant outflow (for NTC-PACL and STC-Control). This suggests that TP was either being added to the water column in the first third of the marsh or that samples had entrained sediment. In all cases, TP levels dropped significantly before reaching the outflow (Exhibits 5-2, 5-67, and 5-68).

Total Dissolved Phosphorus. Treatments in NTC-FeCL and NTC-PACL had a significant impact on TDP concentrations. TDP was being added to the water column in NTC-Control between the inflow and the one-third station. Otherwise, there were no significant changes between stations in any of the cells, suggesting that the marsh had little effect on TDP concentrations (Exhibits 5-2, 5-69, and 5-70).

Soluble Reactive Phosphorous. Treatments in NTC-FeCL and NTC-PACL had a significant impact on SRP concentrations. The marsh did not have any effect on SRP levels in NTC-FeCL, NTC-PACL, or STC-PACL. Concentrations dropped significantly after the one-third station in NTC-Control. There was a significant reduction in SRP in STC-PACL between the plant and the one-third station, but concentrations remained stable afterwards (Exhibits 5-2, 5-71, and 5-72).

Total Kjeldahl Nitrogen. TKN concentrations in NTC-FeCL dropped significantly through the marsh. Chemical treatment did not appear to be having any effect on TKN in NTC-FeCL. Concentrations dropped significantly in NTC-Control after the one-third station. TKN concentrations rose significantly at the one-third station in both NTC-PACL and STC-PACL, but fell before reaching the two-third station (Exhibits 5-2, 5-73, and 5-74). Interestingly, these are the same pattern found with total phosphorous (Exhibits 5-67 and 5-68).

5.3 Summary

In both the calibration and treatment periods, little change in concentrations were seen in calcium, magnesium, sulfate, TDS, and TOC; thus, these do not warrant further consideration. During the calibration and treatment period, NTC-FeCL and NTC-PACL showed an increase in aluminum at the one-third station, but aluminum concentrations dropped off after the one-third station in NTC-PACL. STC-Control and STC-PACL were exporting aluminum during the calibration period. Aluminum levels were reduced by the marsh in STC-PACL during the treatment period.

NTC-FeCL, NTC-PACL, STC-Control, and STC-PACL appeared to be exporting iron at the one-third station for the calibration period. This trend continued during the treatment period in NTC-Control, NTC-PACL, STC-Control, and STC-PACL. Iron concentrations were at a maximum in the plant effluent and outflow of NTC-FeCL during the treatment period. There is a clear drop in iron concentrations as water flows through NTC-FeCL.

Iron and aluminum treatments reduced alkalinity concentrations, but the concentrations in the marsh were stabilized after the one-third station. pH levels in all treatment cells (i.e., NTC-FeCL, NTC-PACL, and STC-PACL) also remained stable through the marsh after the one-third station. Both treatments caused increases in chlorides, which were reduced and stabilized by the marsh.

TP increased significantly between the marsh inflow and the one-third station in NTC-Control, NTC-PACL, STC-Control, and STC-PACL, after which the concentrations dropped off before reaching marsh outflow. This result is interpreted as an artifact resulting from sediments being entrained in the water sample. With the exception of NTC-Control, TDP concentrations were not affected by the marsh. TDP in NTC-Control increased between the inflow and the one-third station. The marsh did not have a significant impact on SRP levels in NTC-FeCL, NTC-PACL, or NTC-Control, but concentrations did drop significantly in NTC-Control and STC-PACL. TKN values dropped significantly through NTC-FeCL and NTC-Control. The TKN concentration at the one-third station of STC-PACL was significantly higher than all other points.

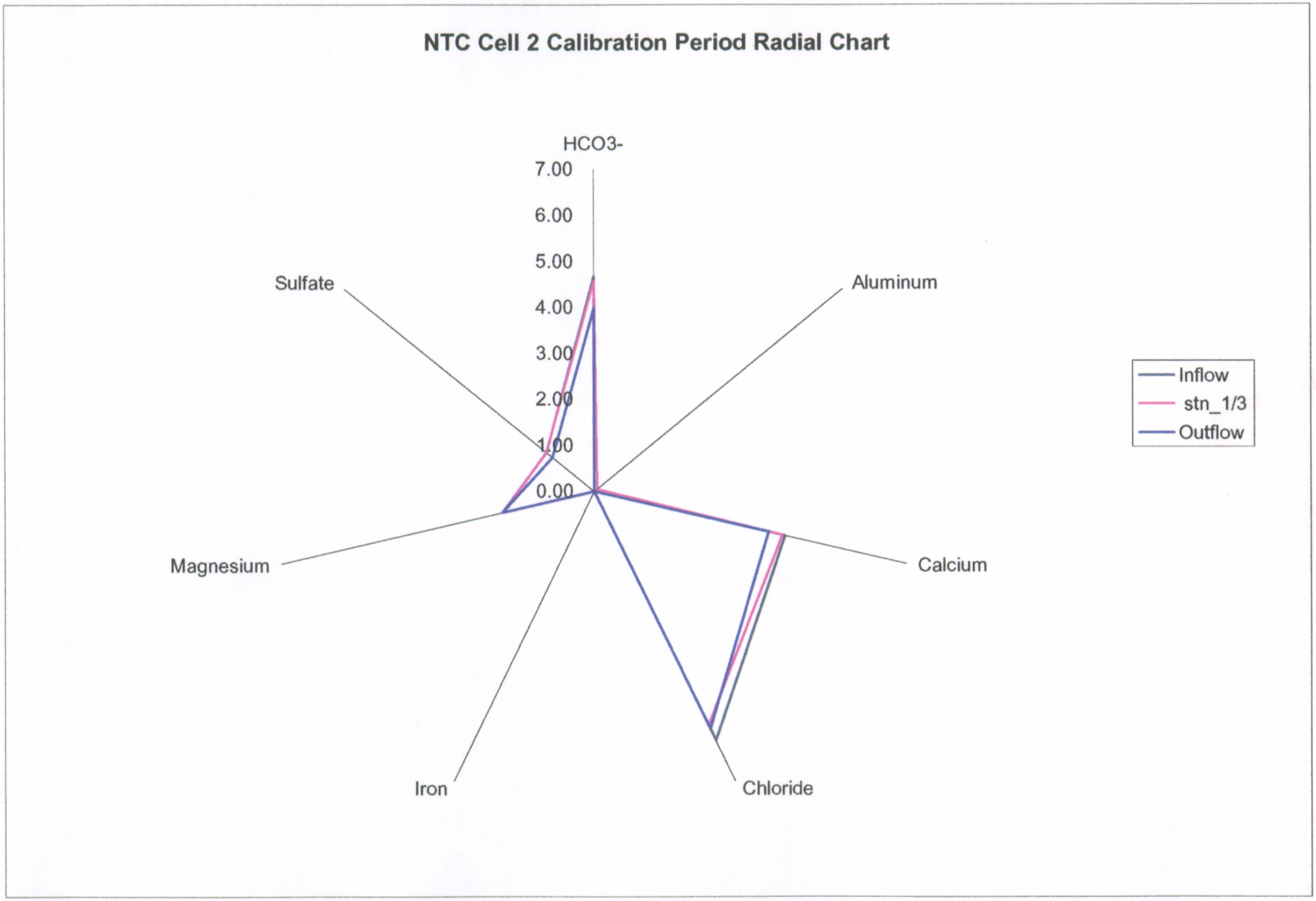


Exhibit 5-3
Radial plot for NTC 2 showing concentrations of ionic parameters in meq/L during the calibration period.

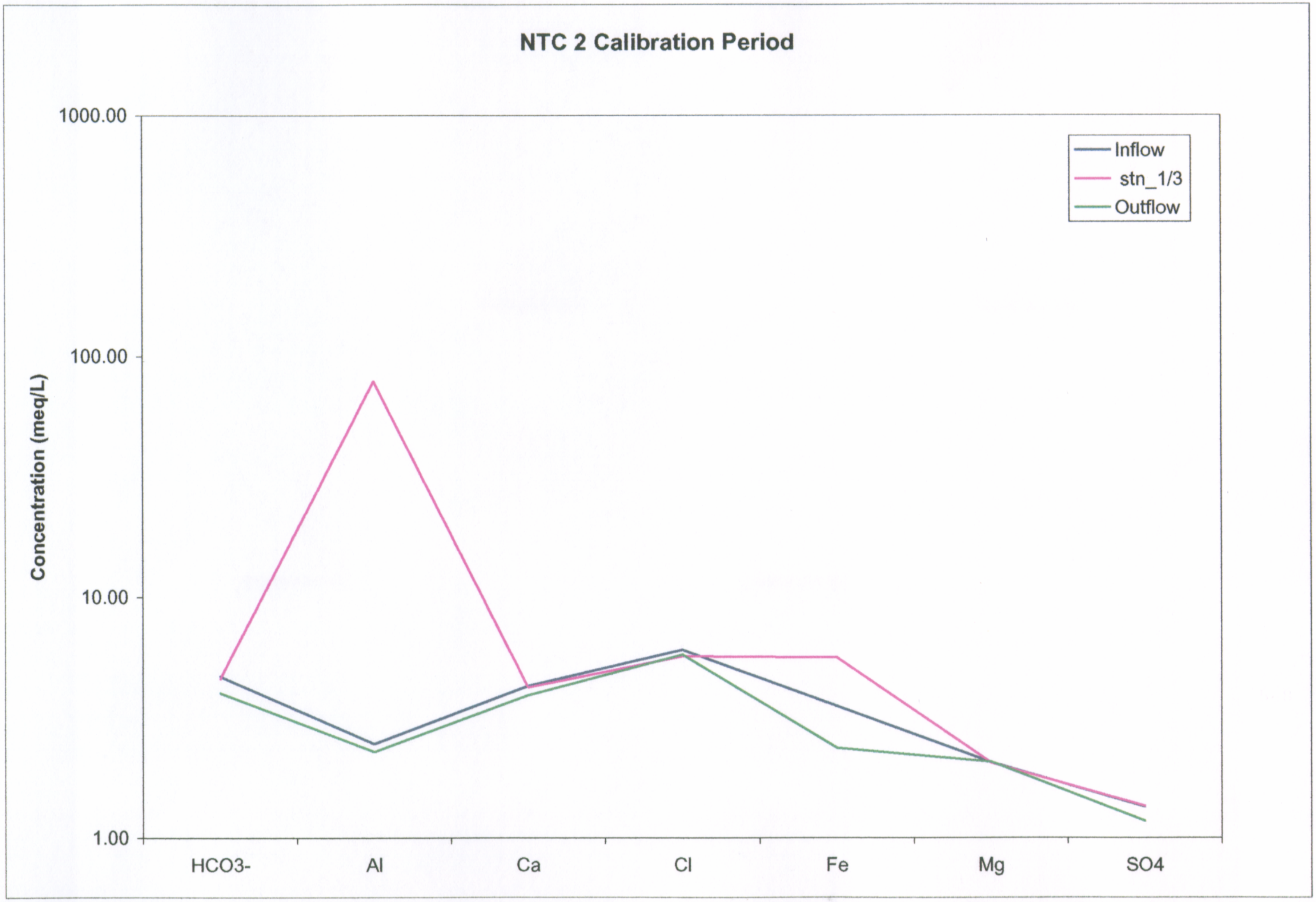


Exhibit 5-4
Schoeller plot for NTC 2 showing concentrations of ionic parameters during the calibration period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

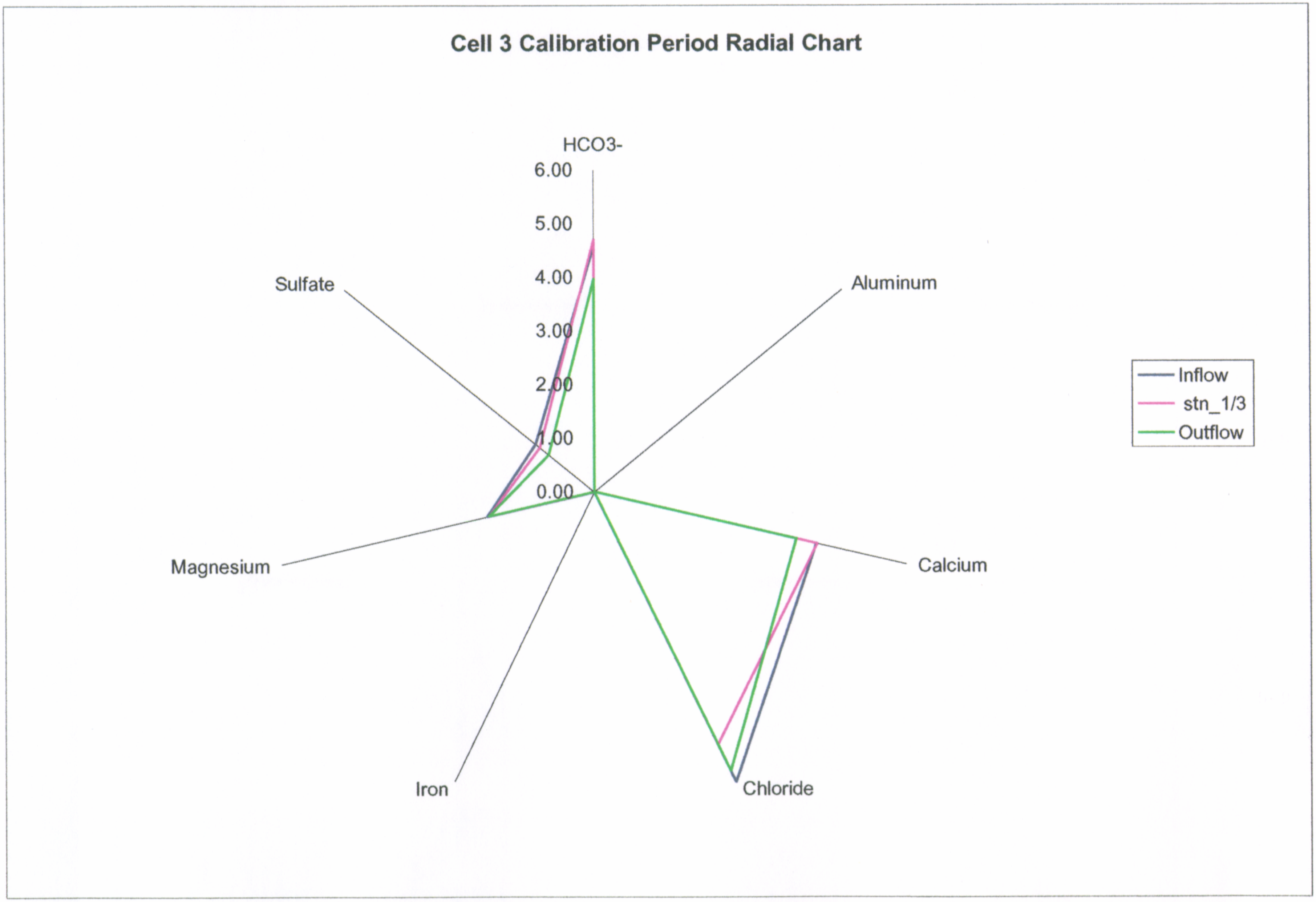


Exhibit 5-5
Radial plot for NTC 3 showing concentrations of ionic parameters in (meq/L) during the calibration period.

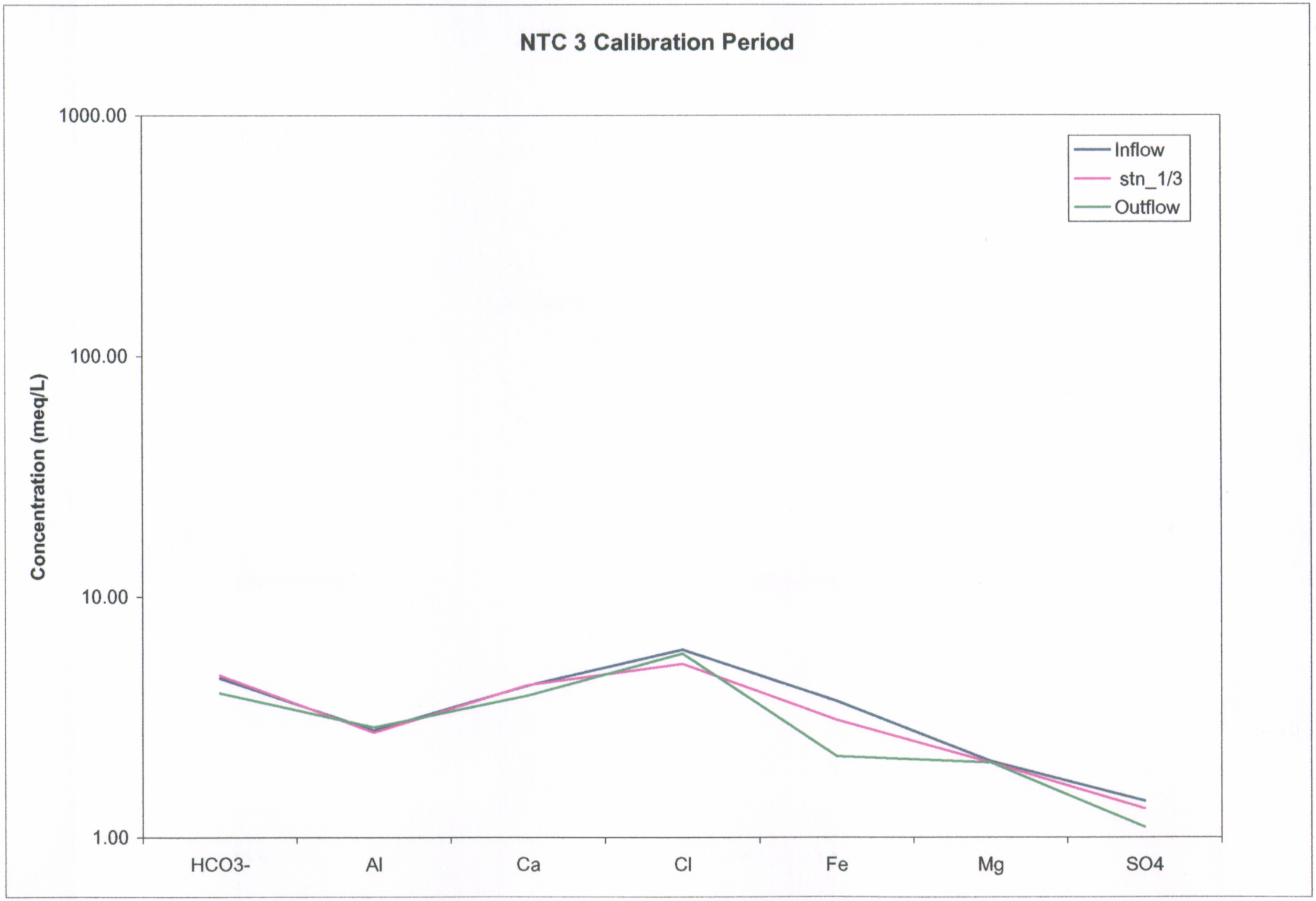


Exhibit 5-6
Schoeller plot for NTC 3 showing concentrations of ionic parameters during the calibration period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

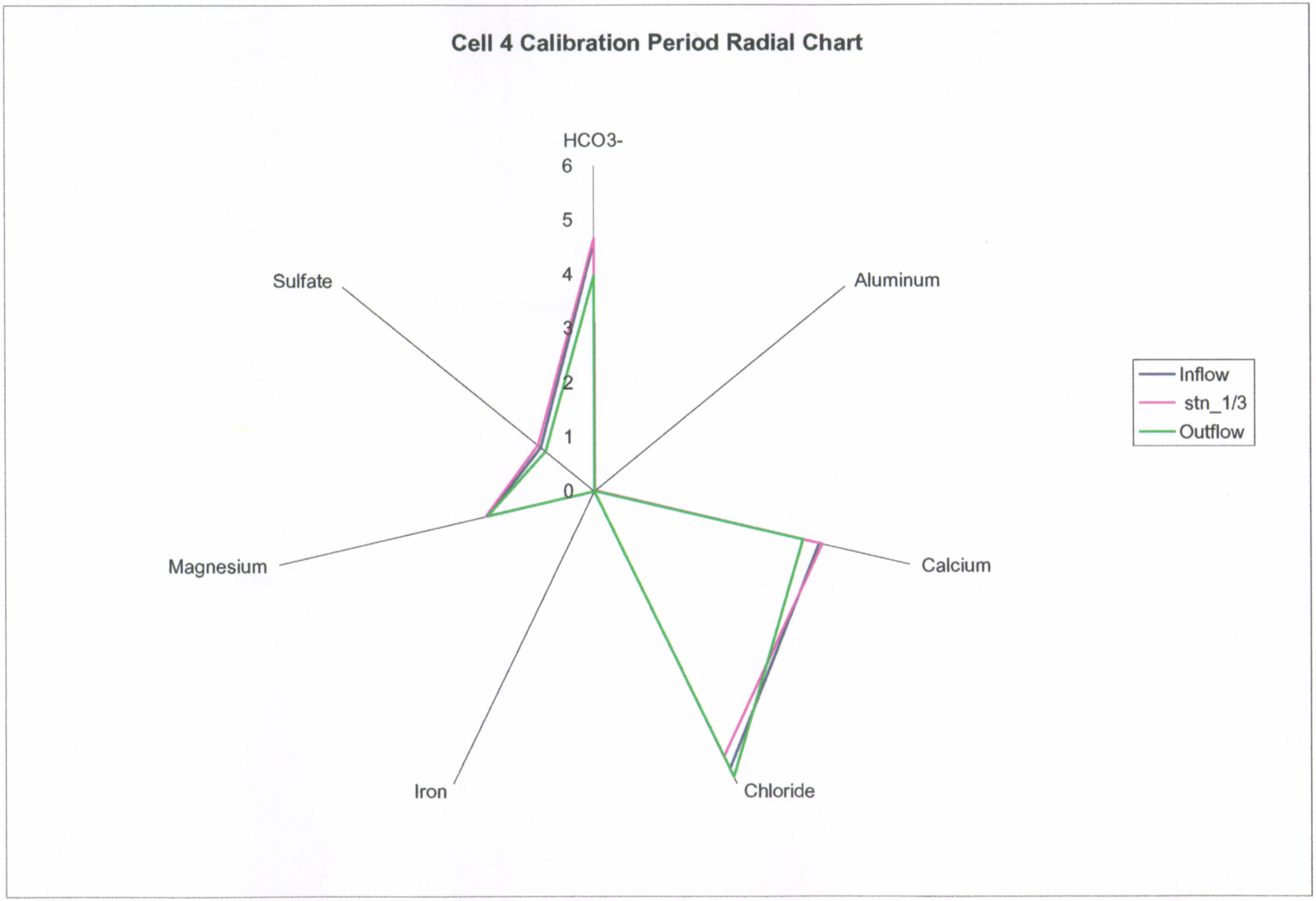


Exhibit 5-7
Radial plot for NTC 4 showing concentrations of ionic parameters in meq/L during the calibration period.

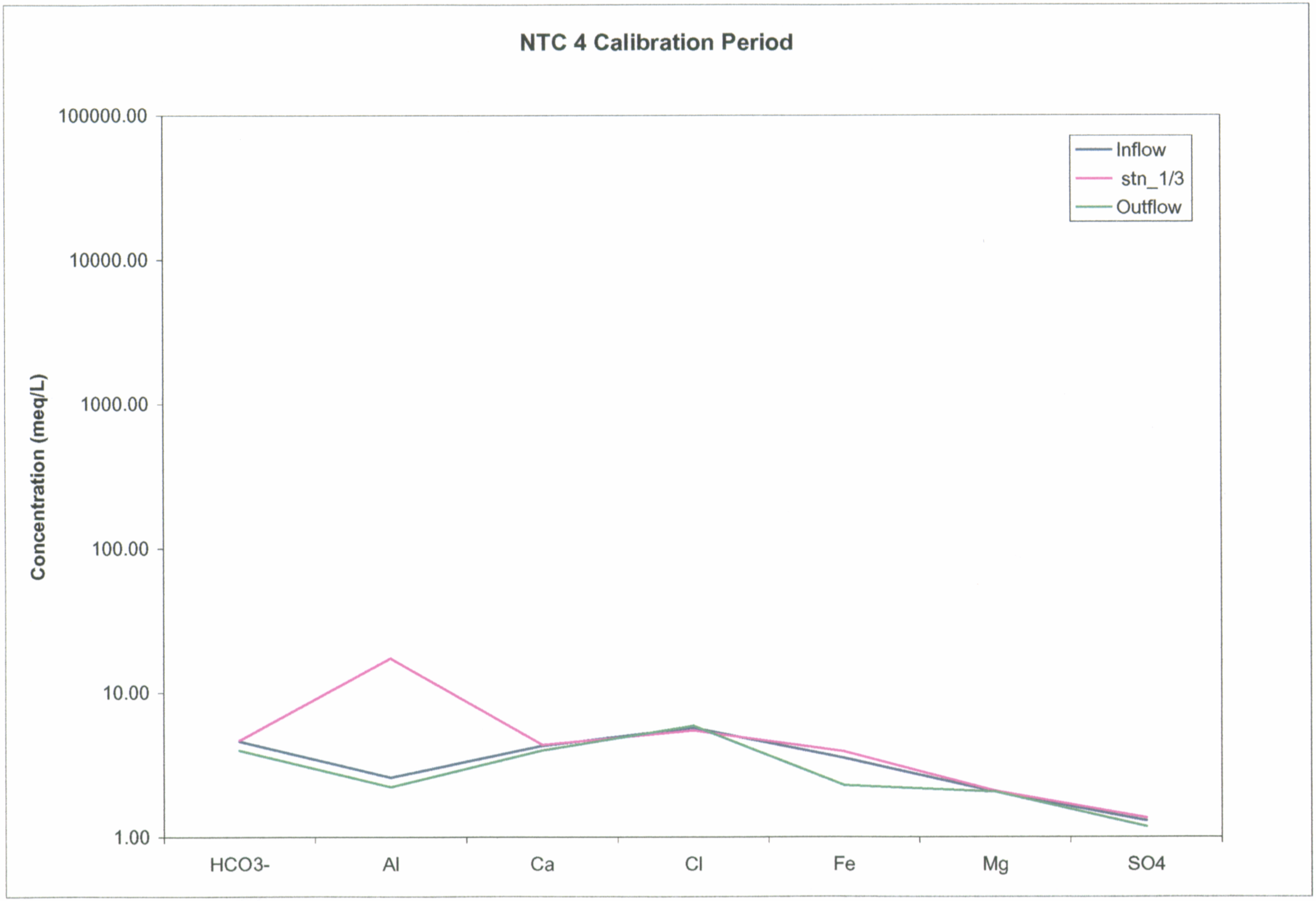


Exhibit 5-8
Schoeller plot for NTC 4 showing concentrations of ionic parameters during the calibration period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

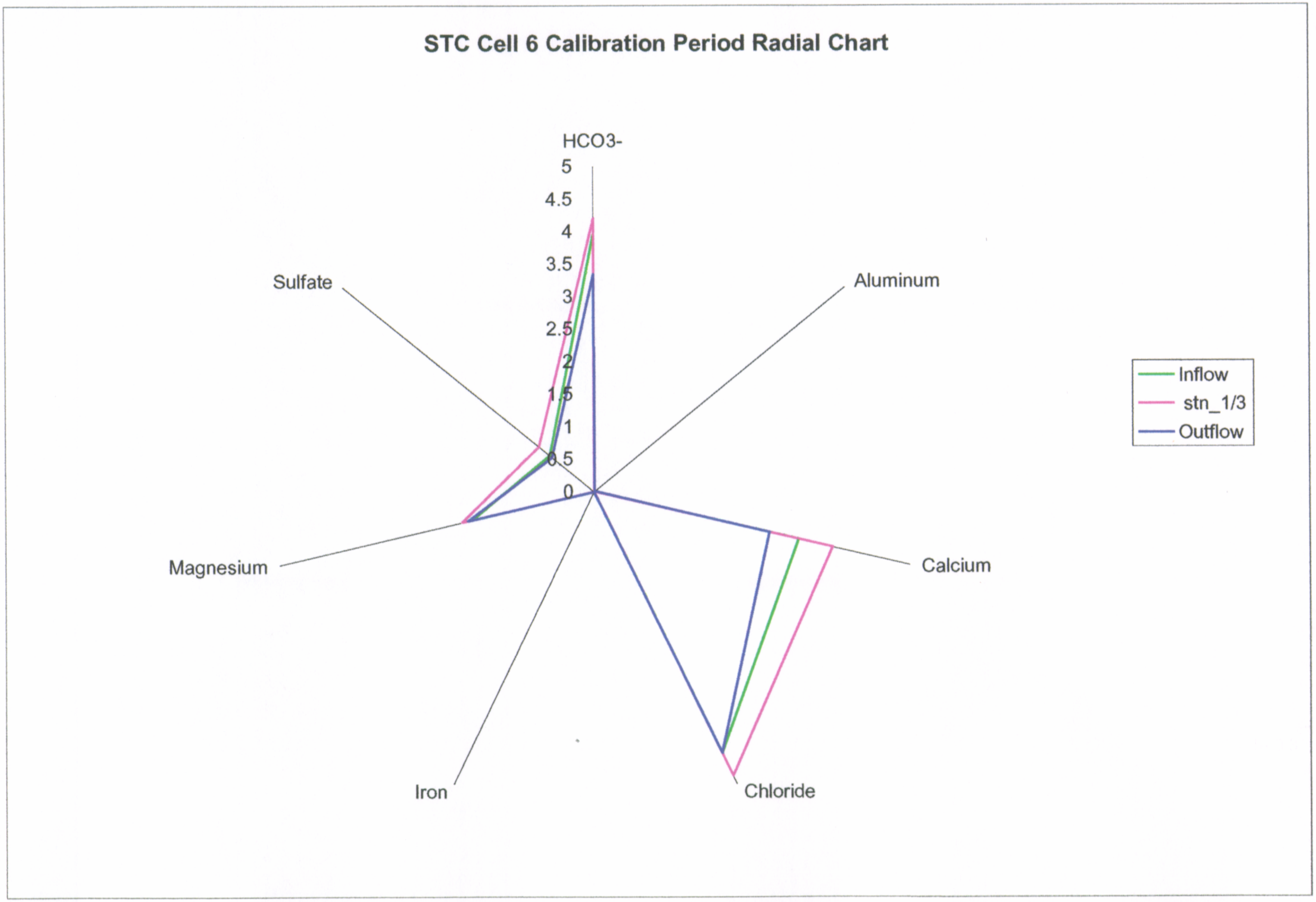


Exhibit 5-9
Radial plot for STC 6 showing concentrations of ionic parameters in meq/L during the calibration period.

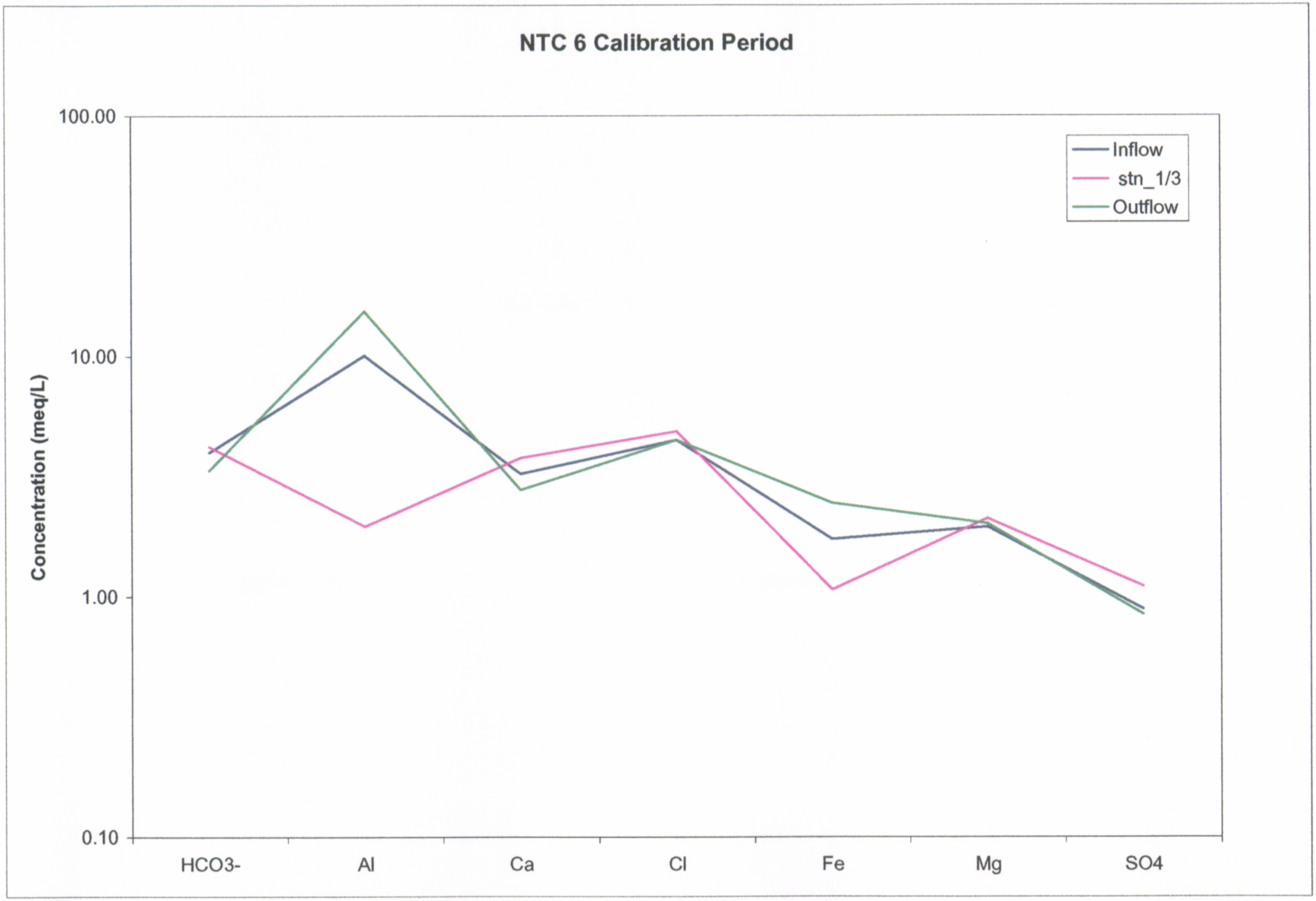


Exhibit 5-10
Schoeller plot for NTC 6 showing concentrations of ionic parameters during the calibration period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

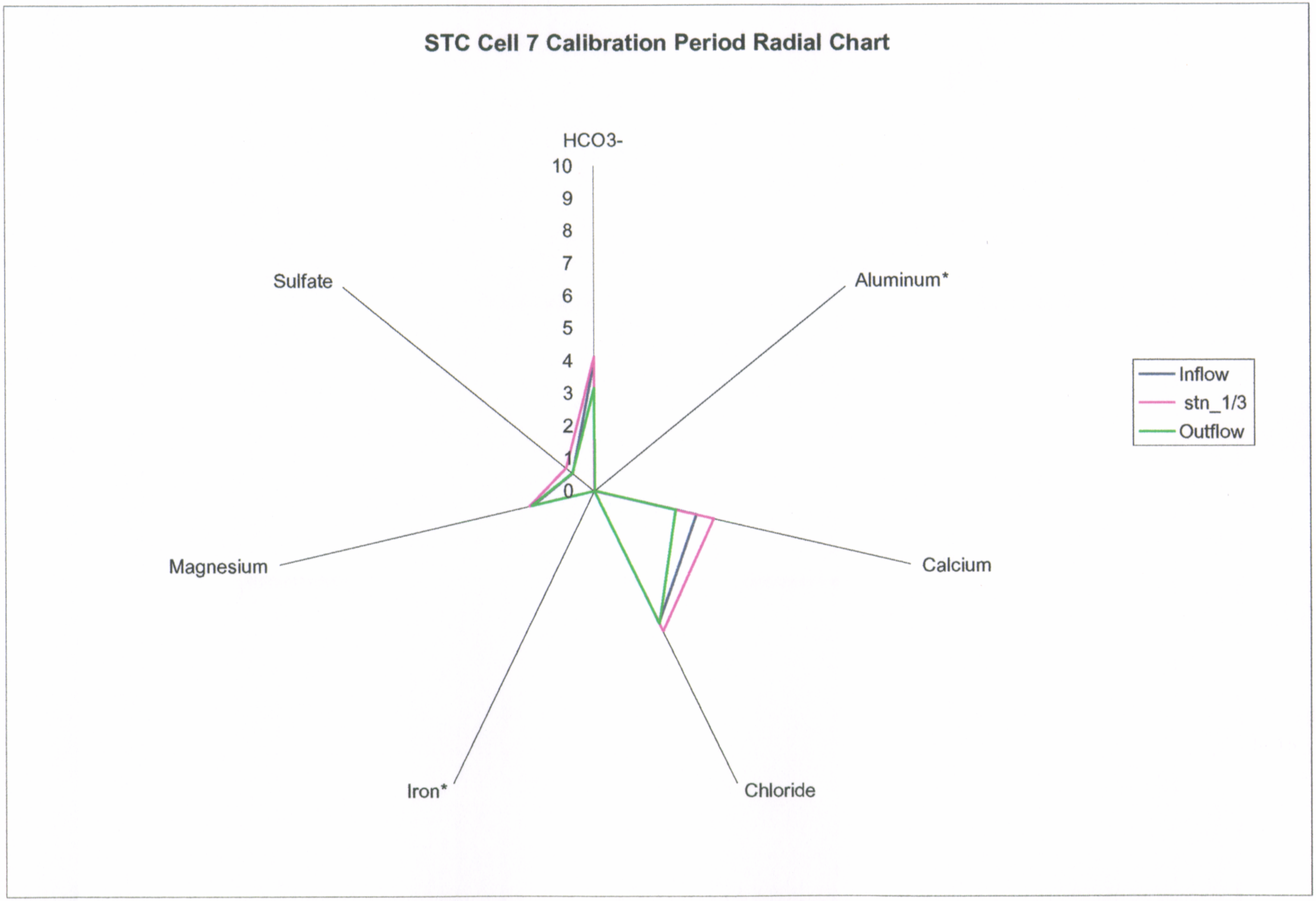


Exhibit 5-11
Radial plot for STC 7 showing concentrations of ionic parameters in meq/L for the calibration period.

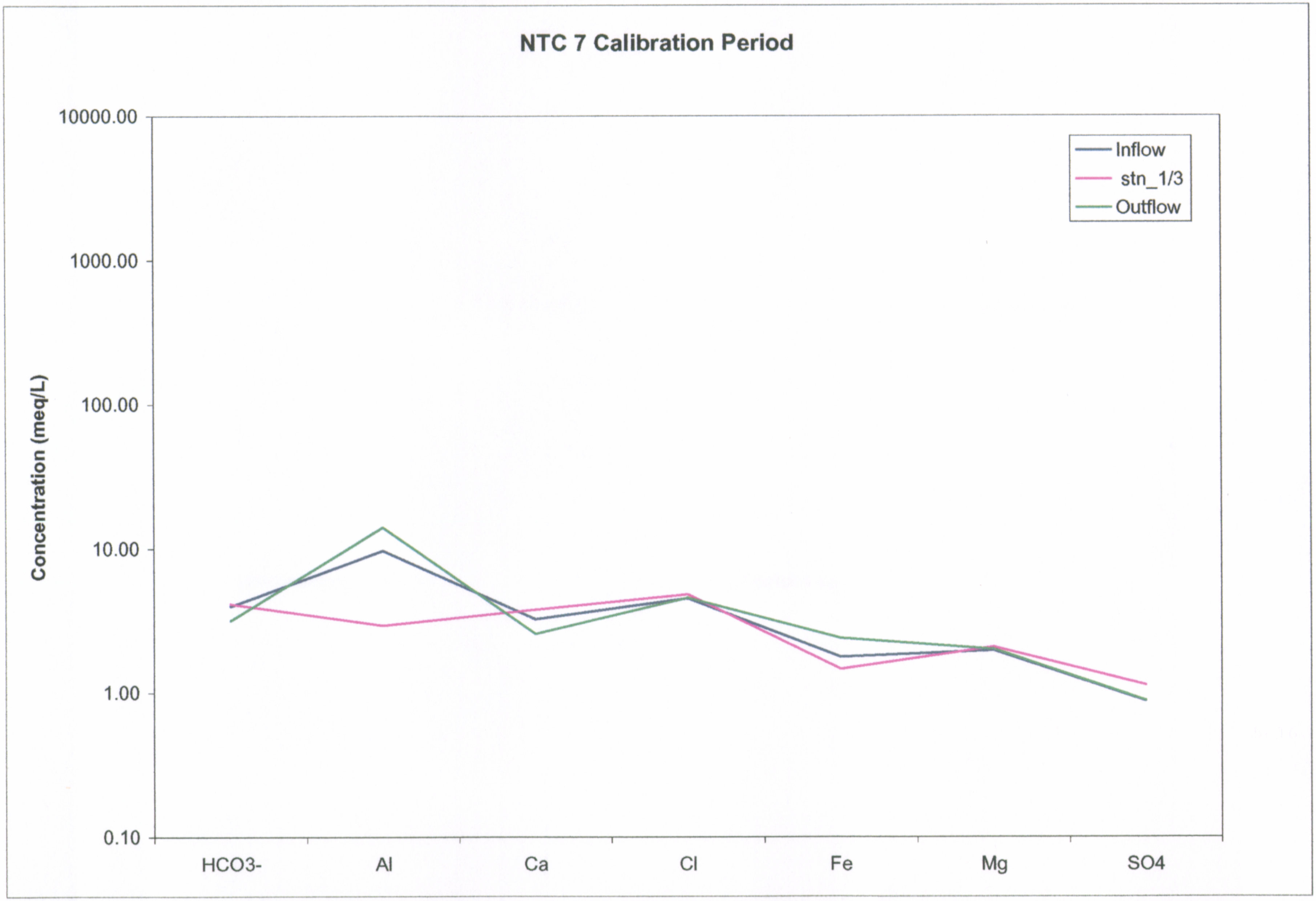


Exhibit 5-12
Schoeller plot for NTC 7 showing concentrations of ionic parameters during the calibration period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

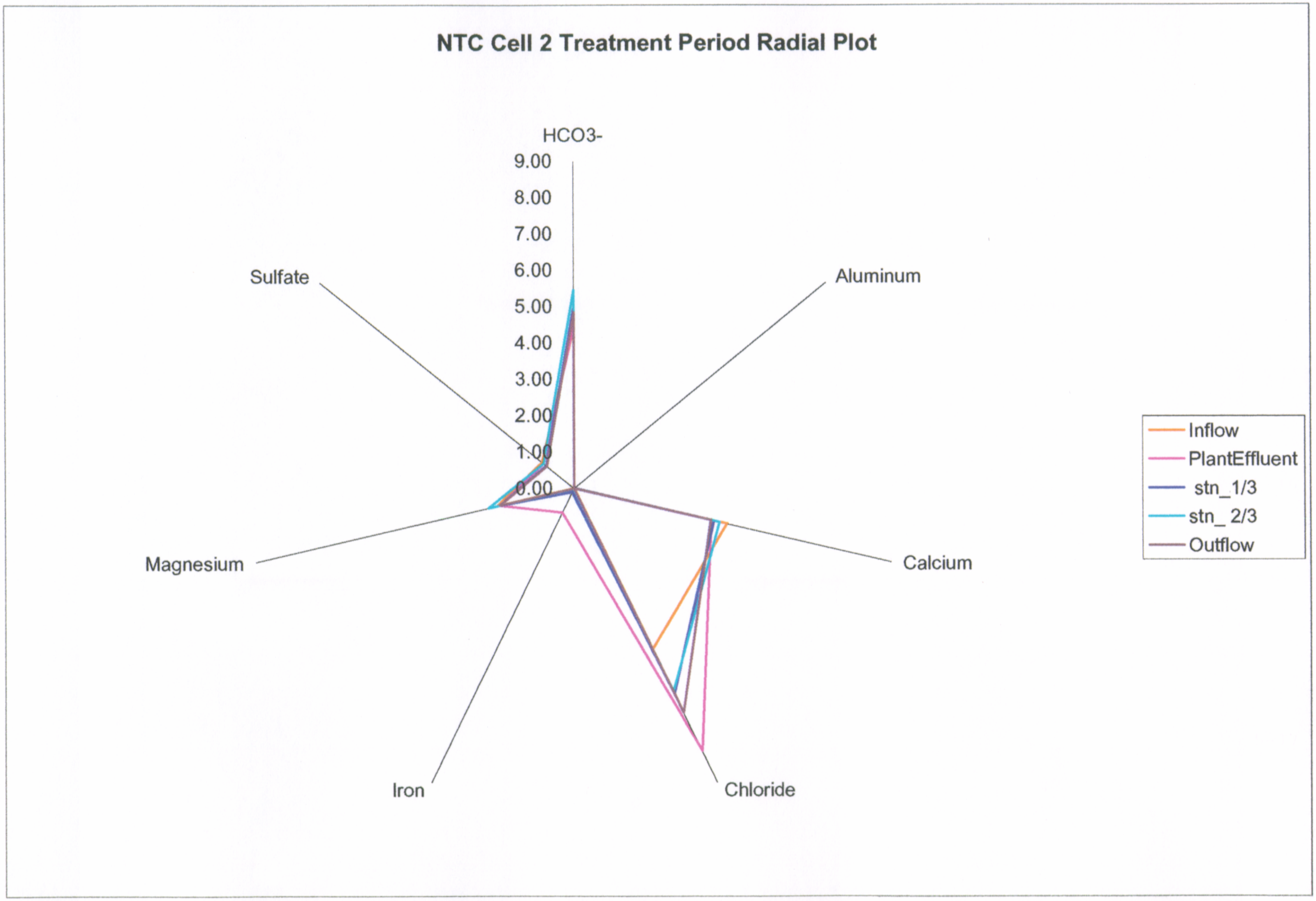


Exhibit 5-13
Radial plot for NTC 2 showing concentrations of ionic parameters in meq/L during the treatment period.

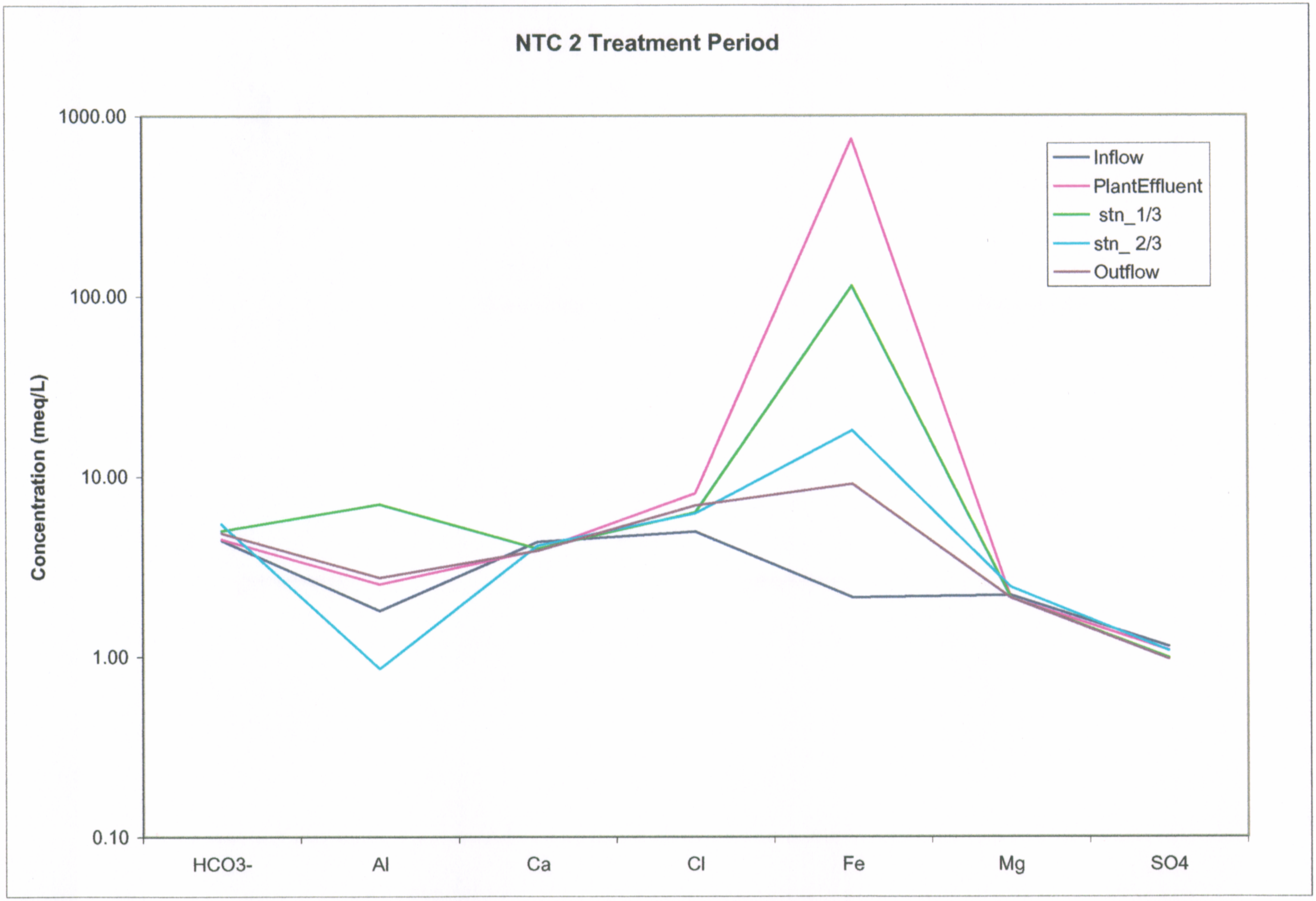


Exhibit 5-14
Schoeller plot for NTC 2 showing concentrations of ionic parameters during the treatment period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

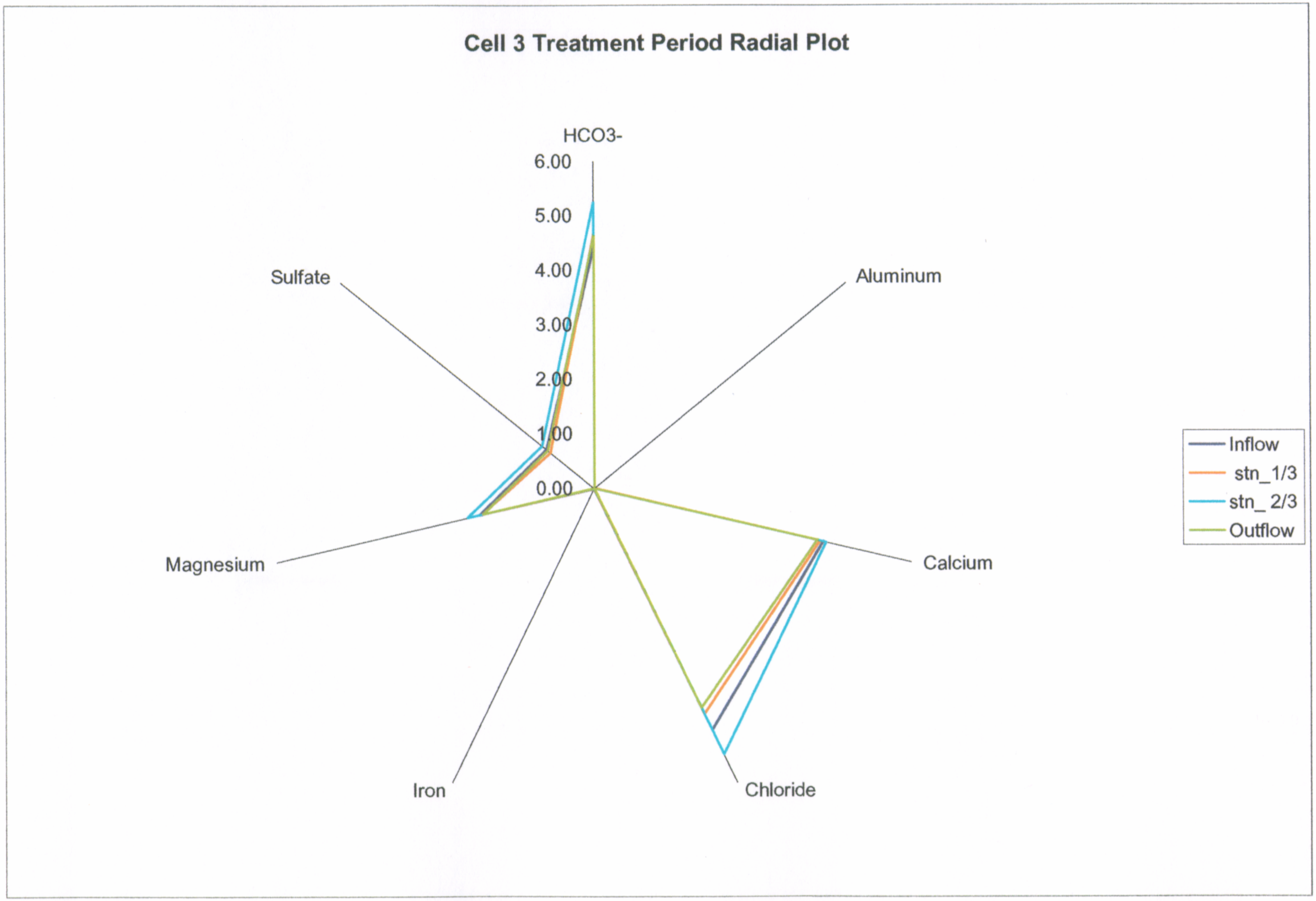


Exhibit 5-15
Radial plot for NTC 3 showing concentrations of ionic parameters during the treatment period.

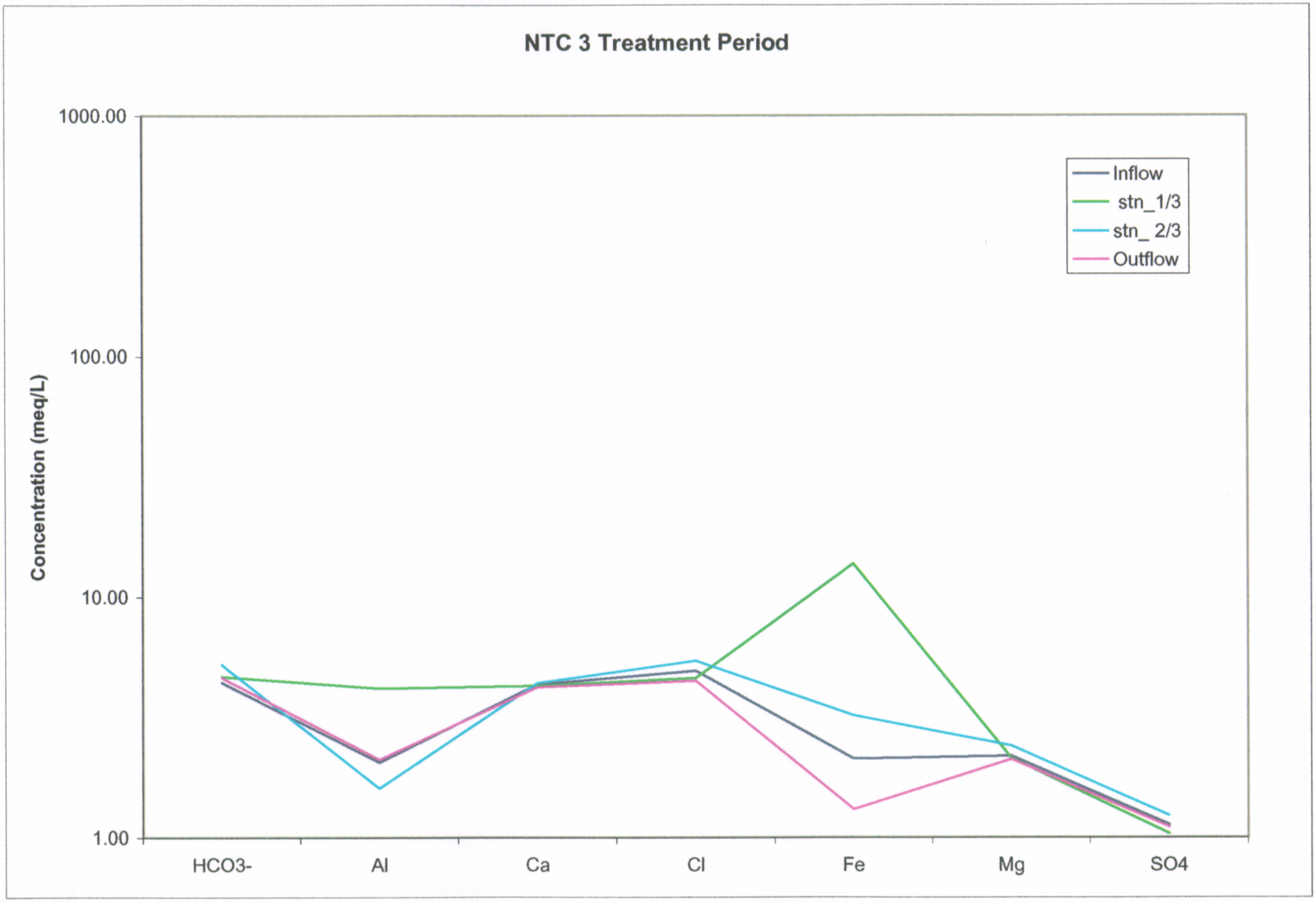


Exhibit 5-16
Schoeller plot for NTC 3 showing concentrations of ionic parameters during the treatment period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

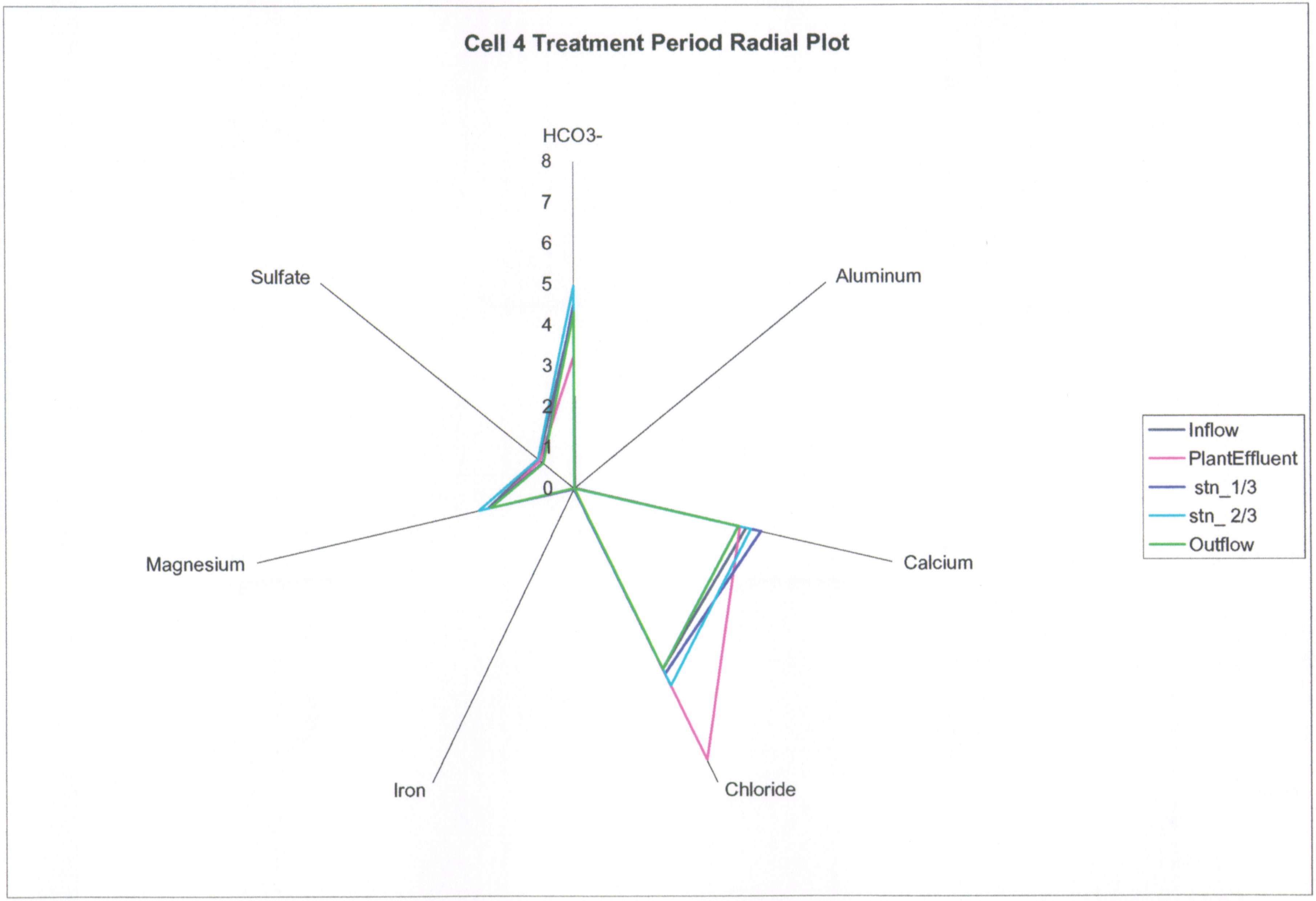


Exhibit 5-17
Radial plot for NTC 4 showing concentrations of ionic parameters in meq/L during the treatment period.

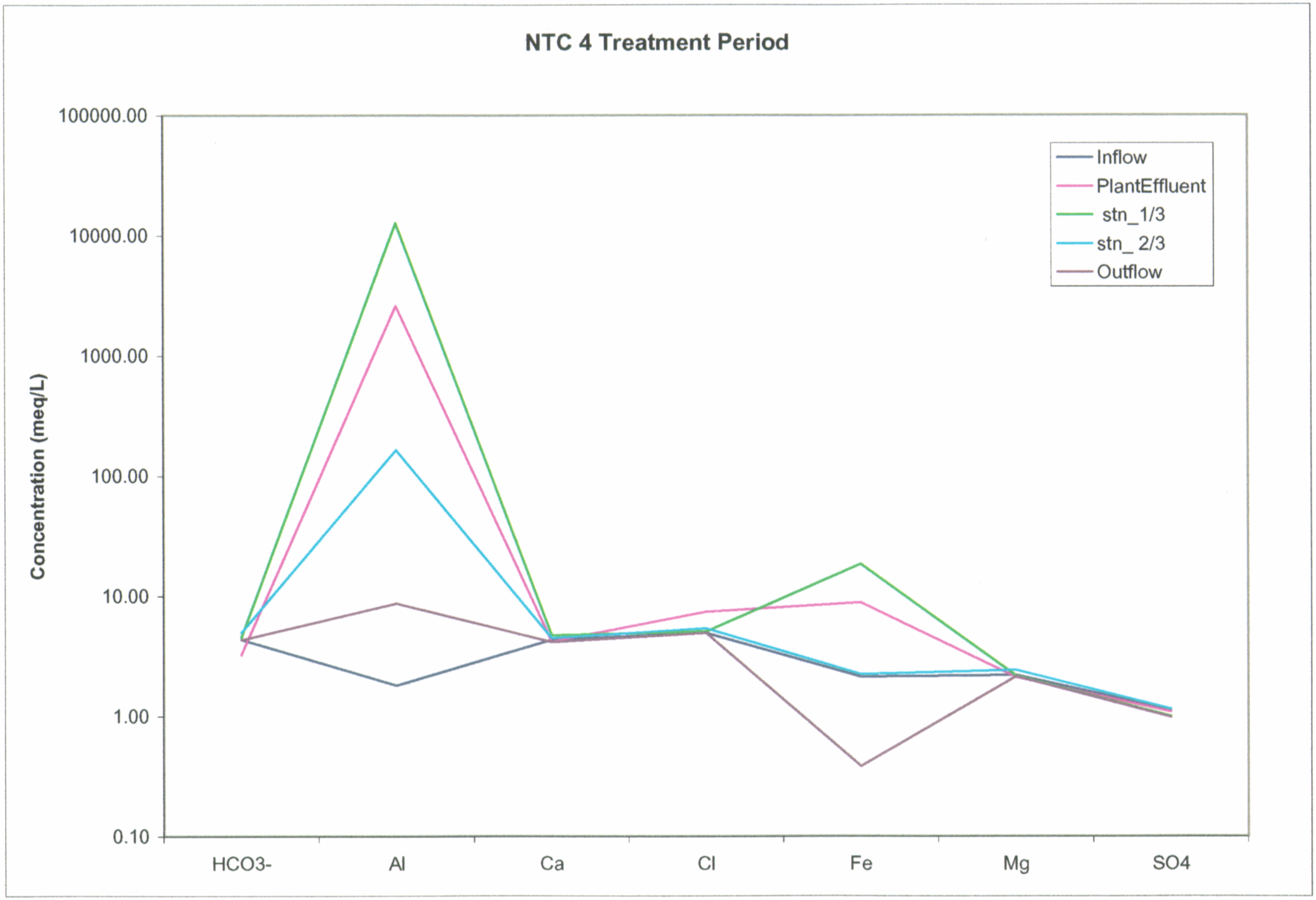


Exhibit 5-18
Schoeller plot for NTC 4 showing concentrations of ionic parameters during the treatment period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

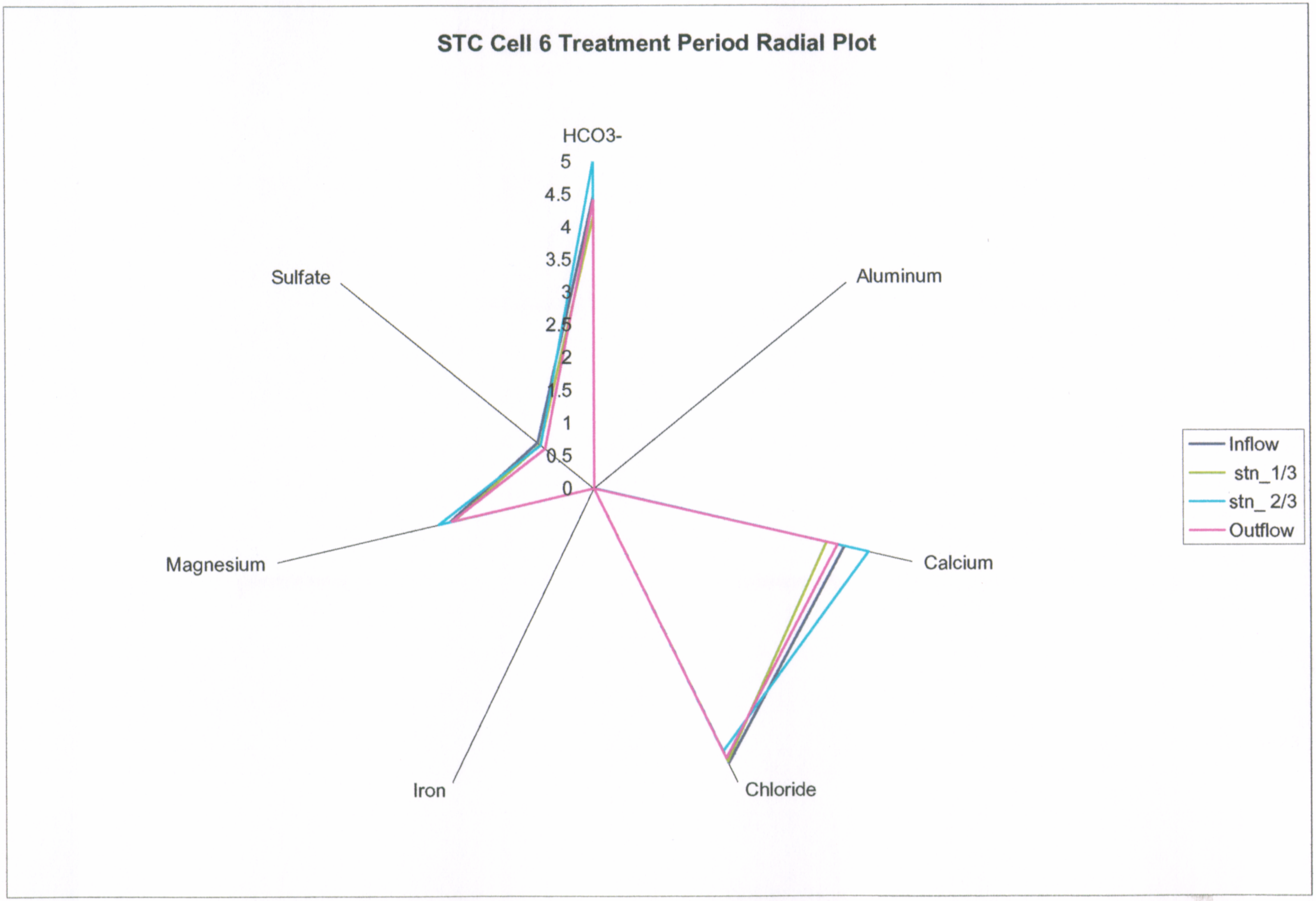


Exhibit 5-19
Radial plot for STC 6 showing concentrations of ionic parameters in meq/L during the treatment period.

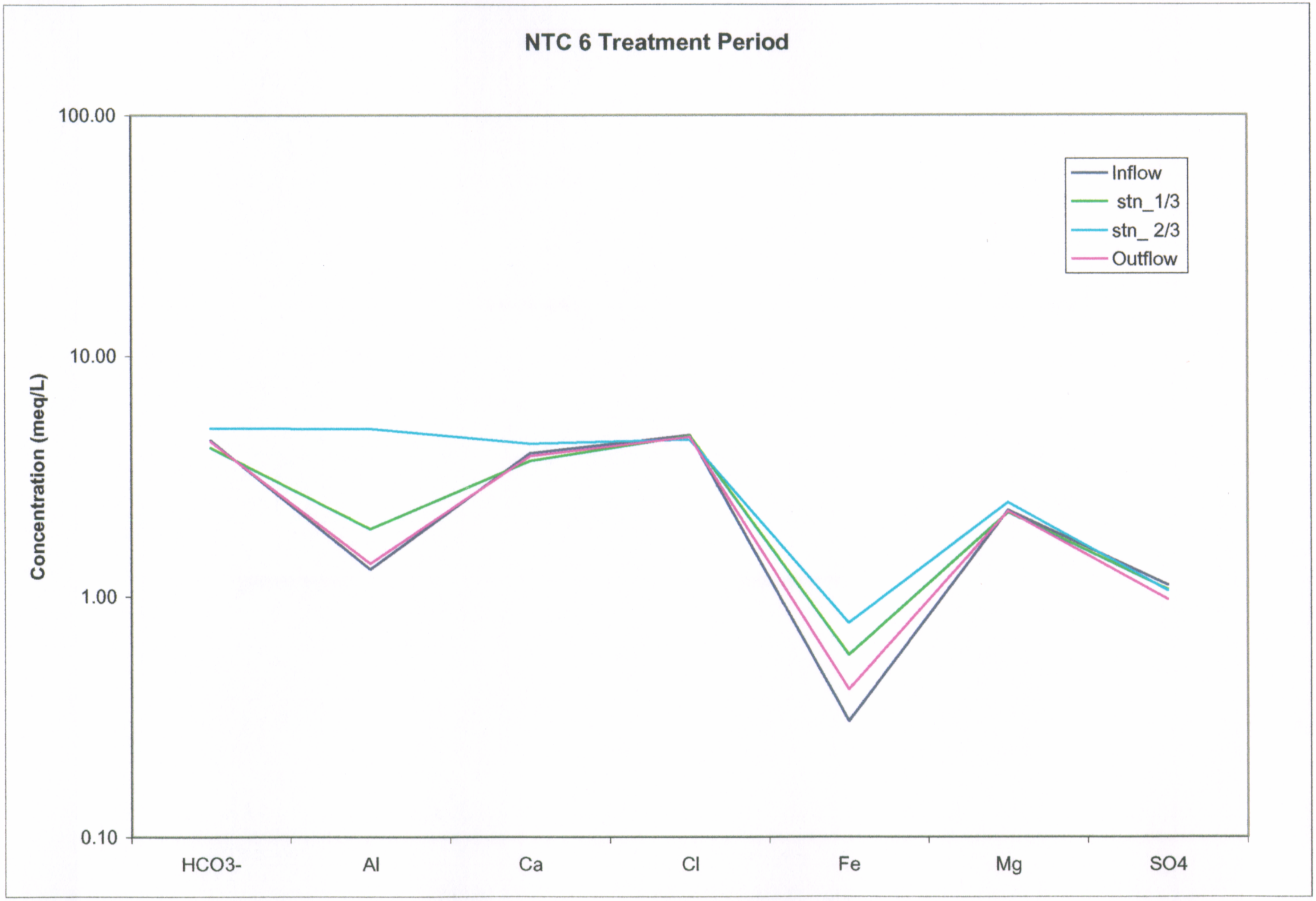


Exhibit 5-20
Schoeller plot for NTC 6 showing concentrations of ionic parameters during the treatment period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

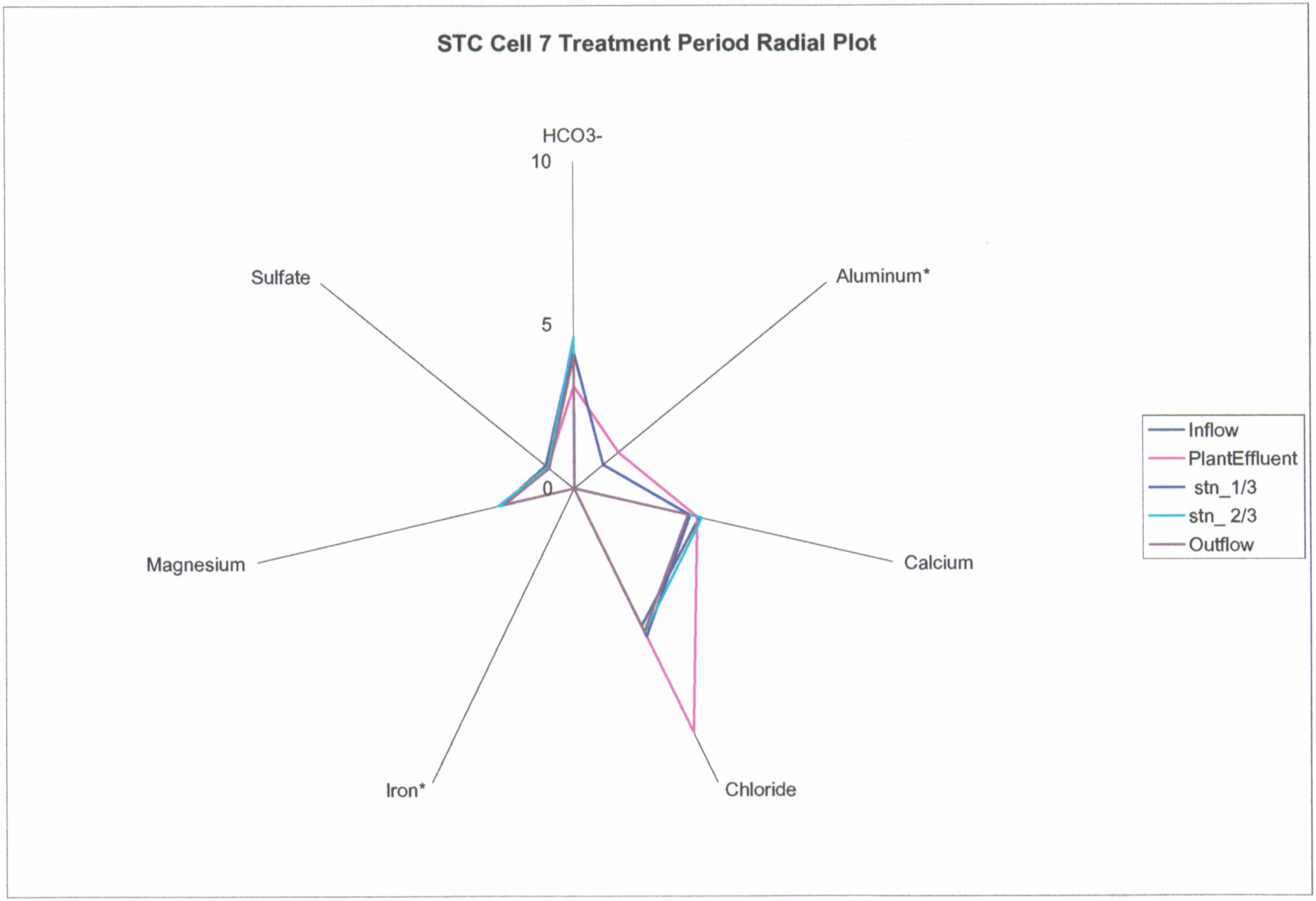


Exhibit 5-21
Radial plot for STC 7 showing concentrations of ionic parameters in meq/L during the treatment period.

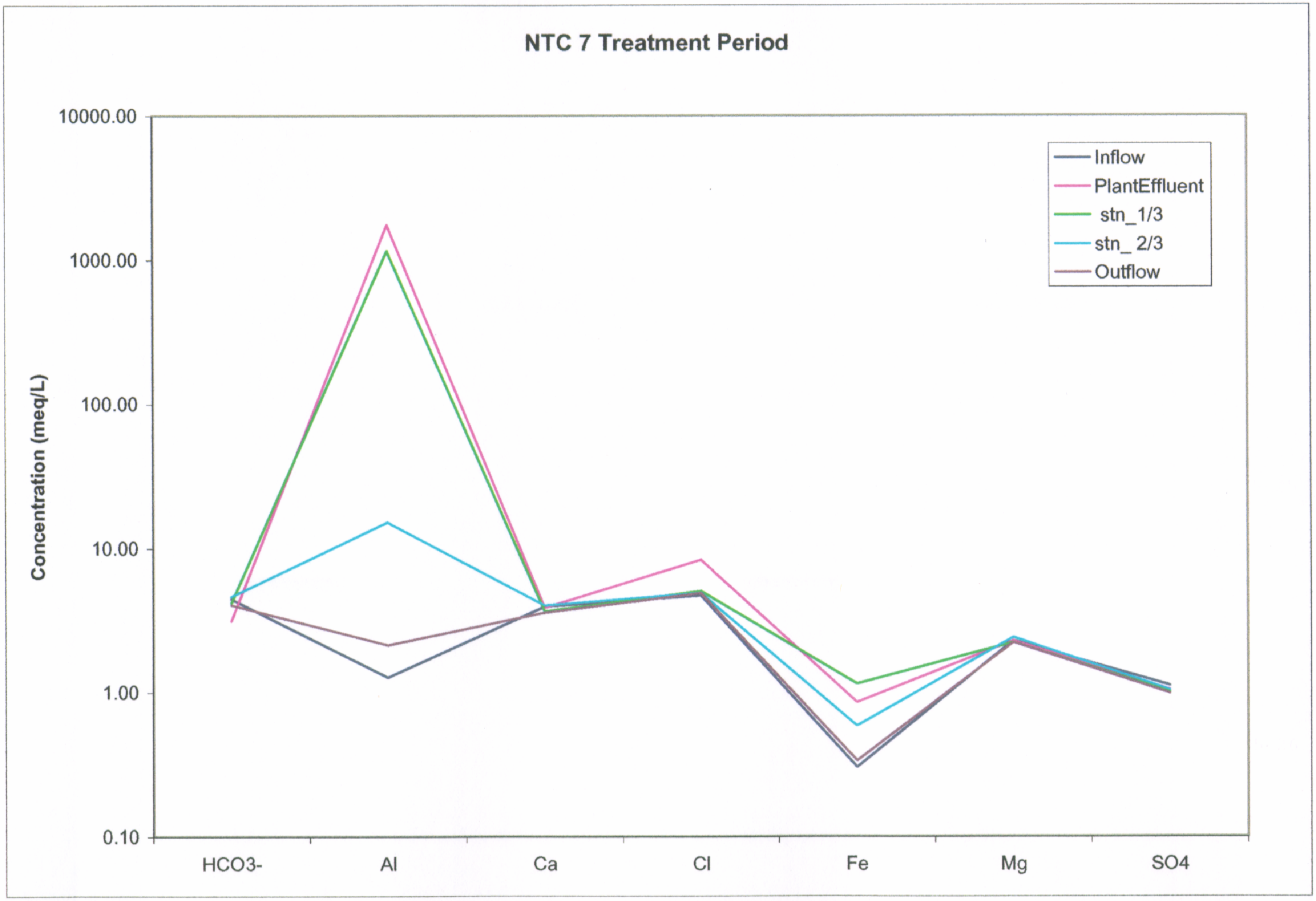


Exhibit 5-22
Schoeller plot for NTC 7 showing concentrations of ionic parameters during the treatment period.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

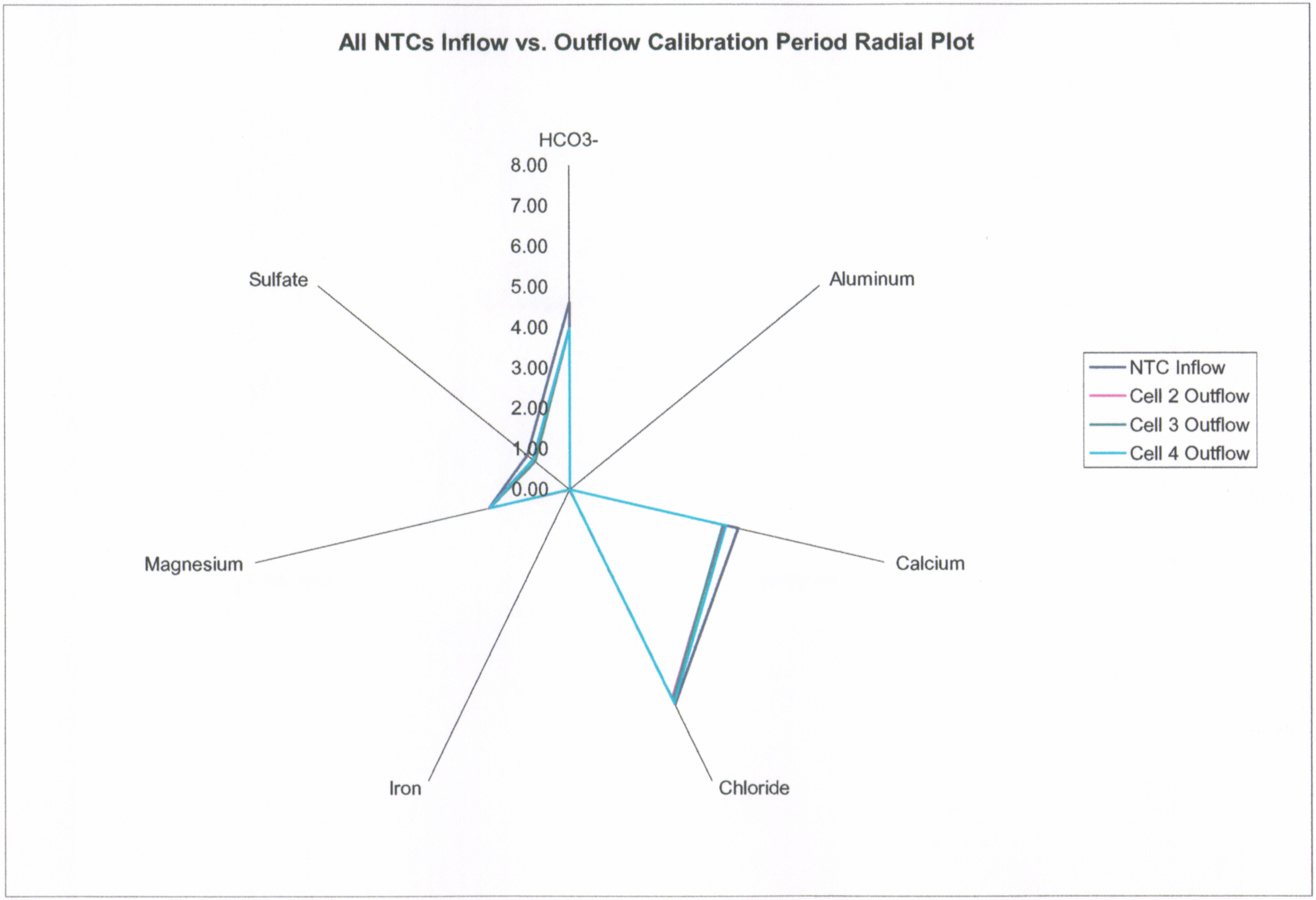


Exhibit 5-23
Radial plot comparing Inflow vs. Outflow for the NTCs during the calibration period in meq/L.

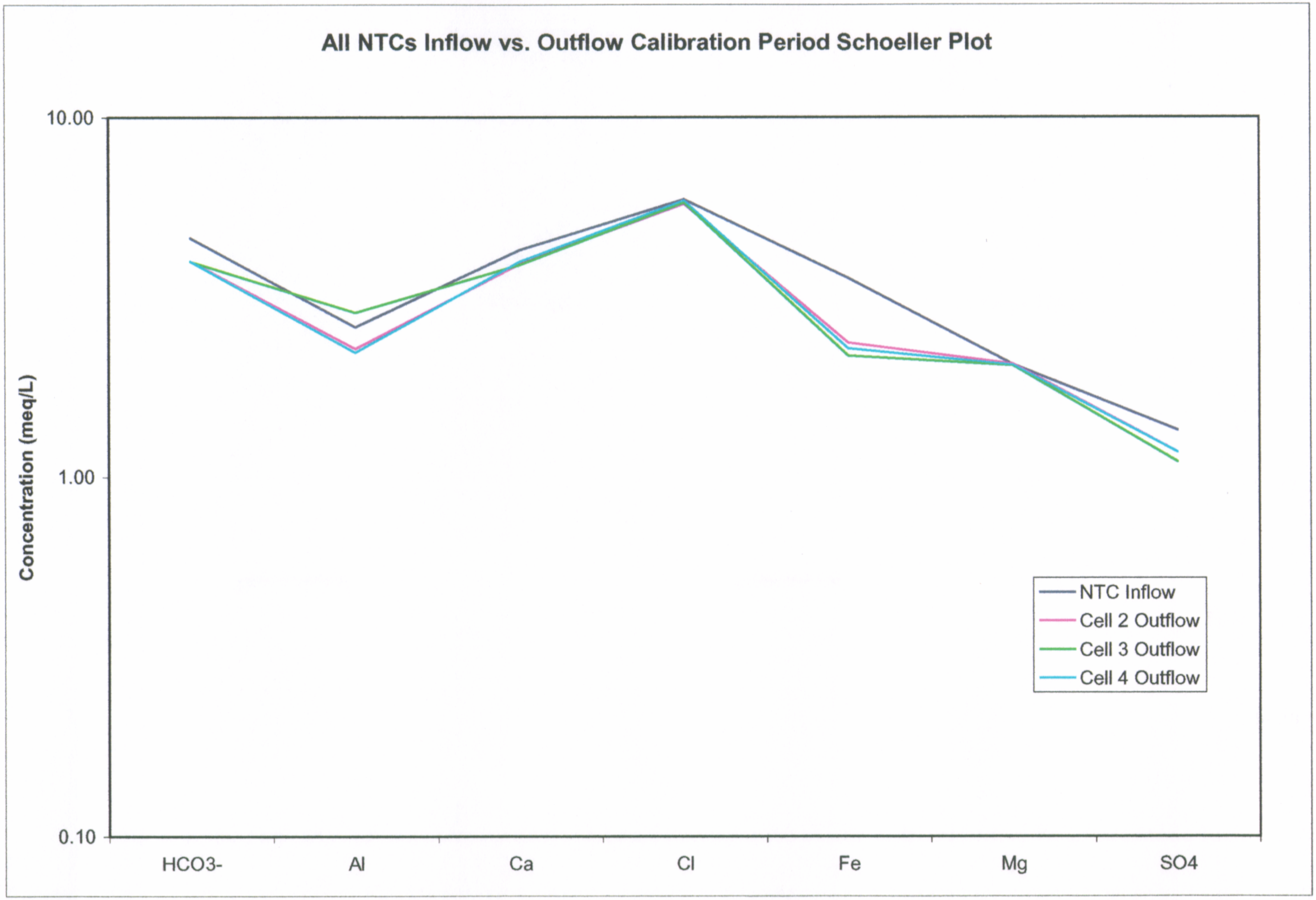


Exhibit 5-24
Schoeller plot comparing Inflow vs. Outflow for the NTCs during the calibration period.
Note: Concentrations of Iron and Aluminum are expressed in microeq/L.

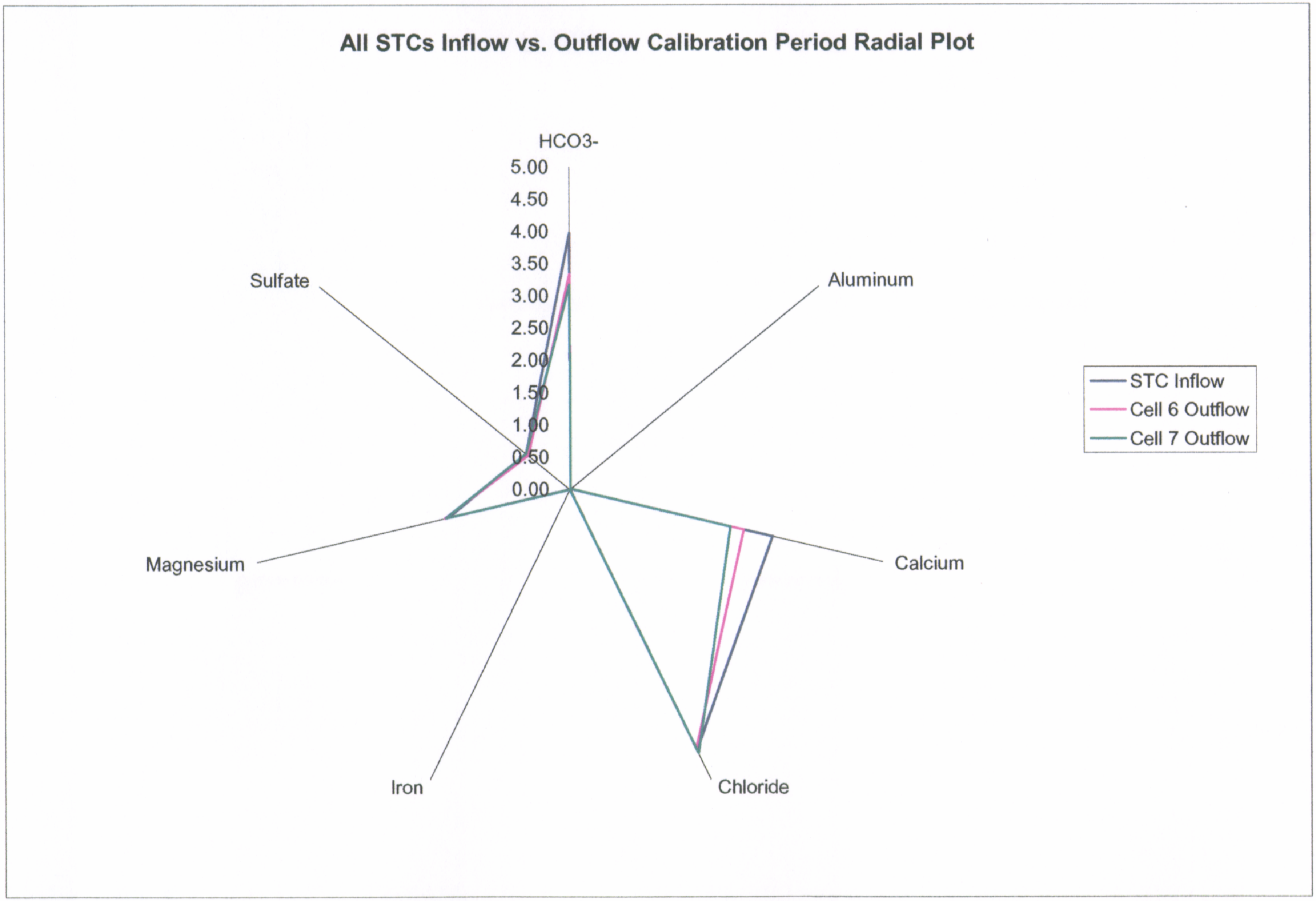


Exhibit 5-25
Radial plot comparing Inflow vs. Outflow for the STCs during the calibration period in meq/L.

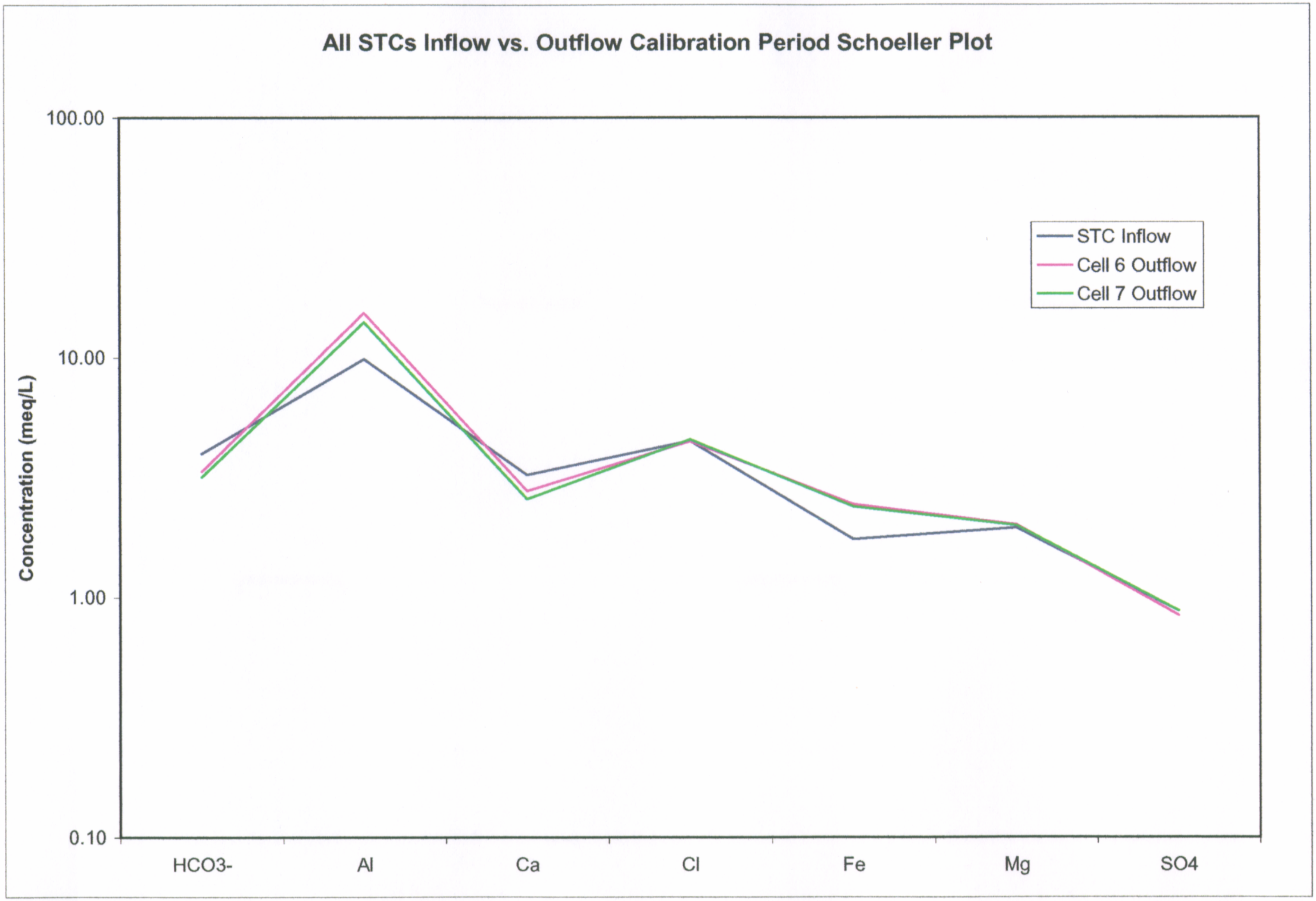


Exhibit 5-26
Schoeller plot comparing Inflow vs. Outflow for the STCs during the calibration period.
Note: Concentrations of Iron and Aluminum are expressed in microeq/L.

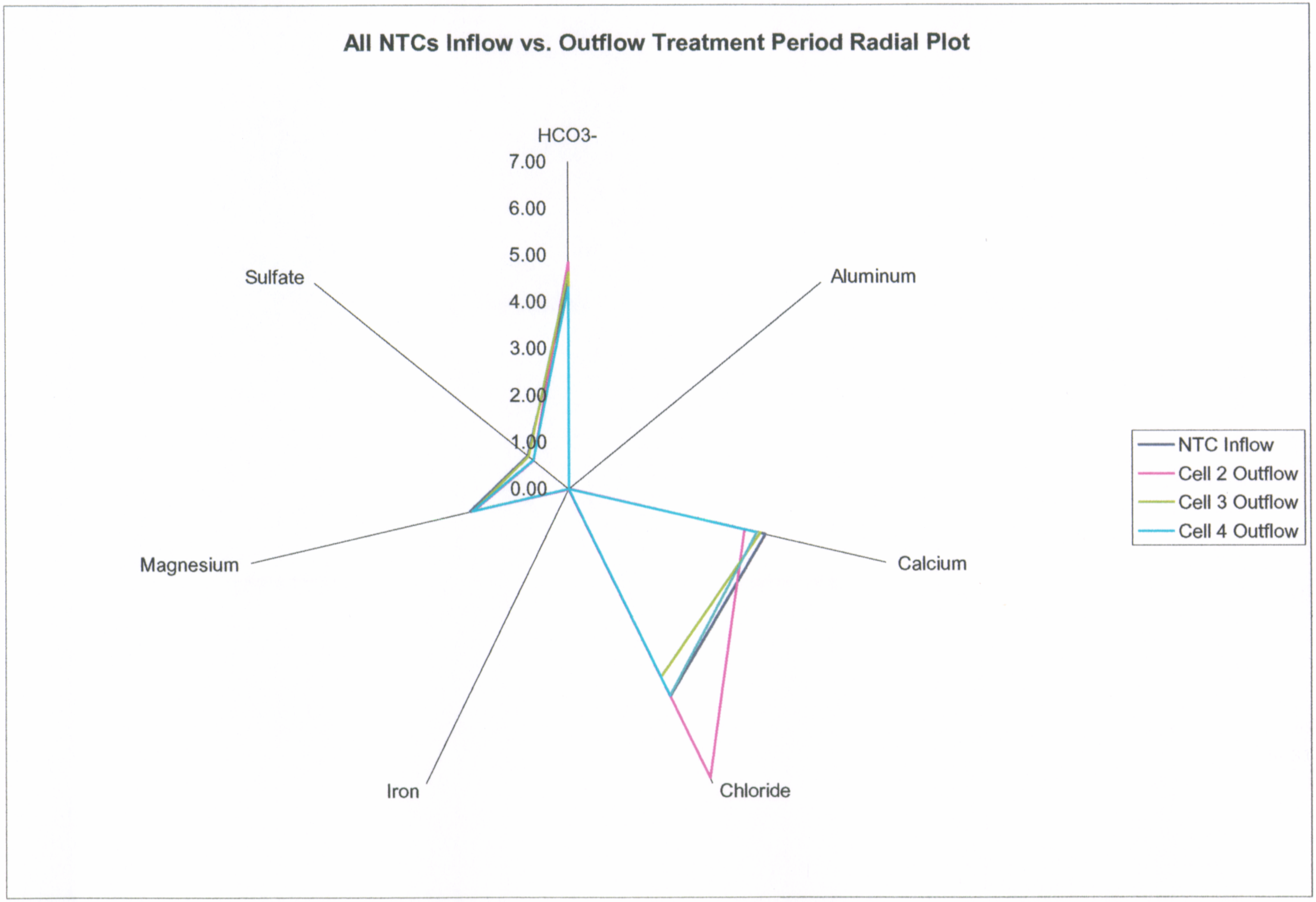


Exhibit 5-27
Radial plot comparing Inflow vs. Outflow in the NTCs during the treatment period in meq/L.

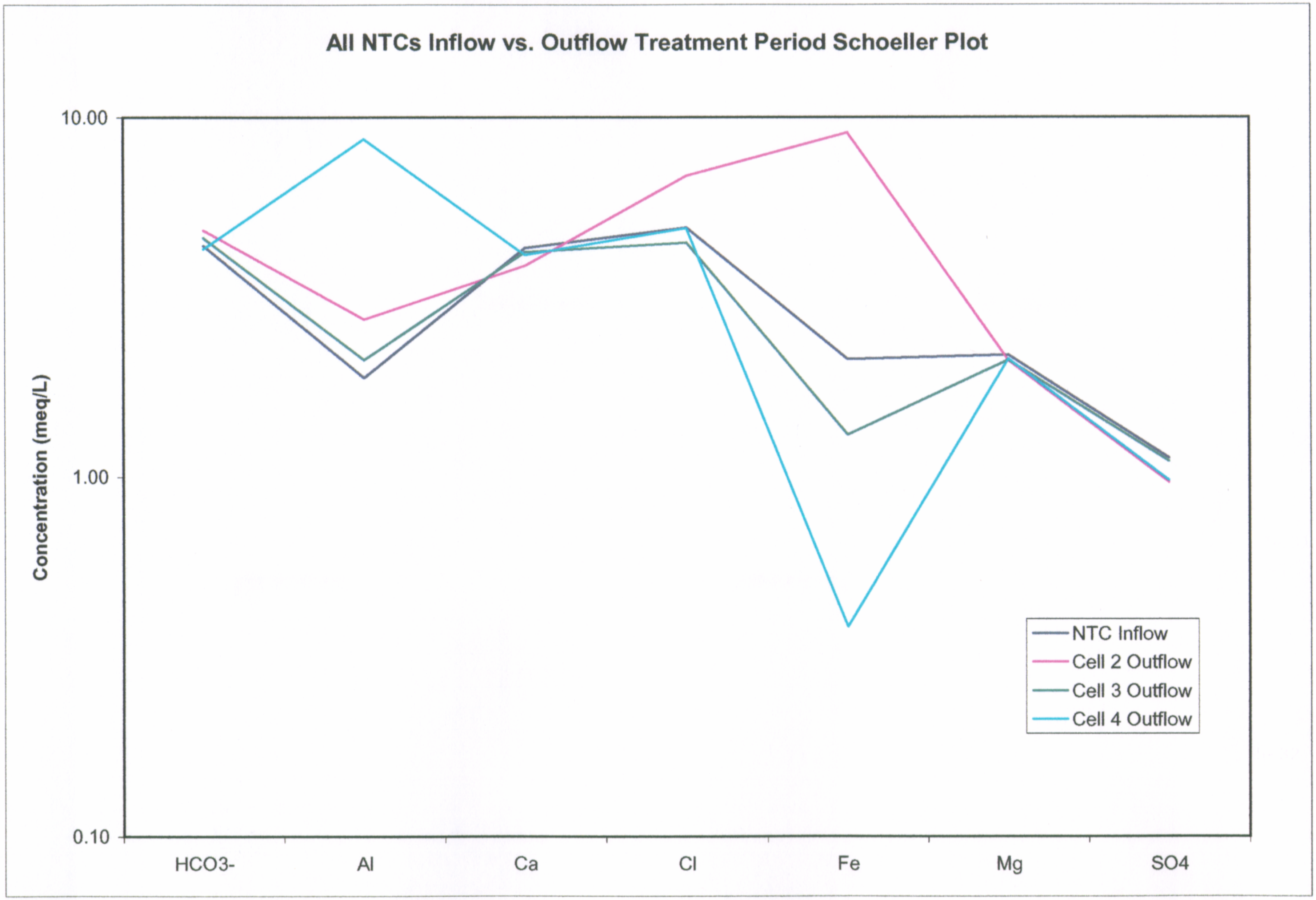


Exhibit 5-28
Schoeller plot comparing Inflow vs. Outflow for the NTCs during the treatment period.
Note: Concentrations of Iron and Aluminum are expressed in microeq/L.

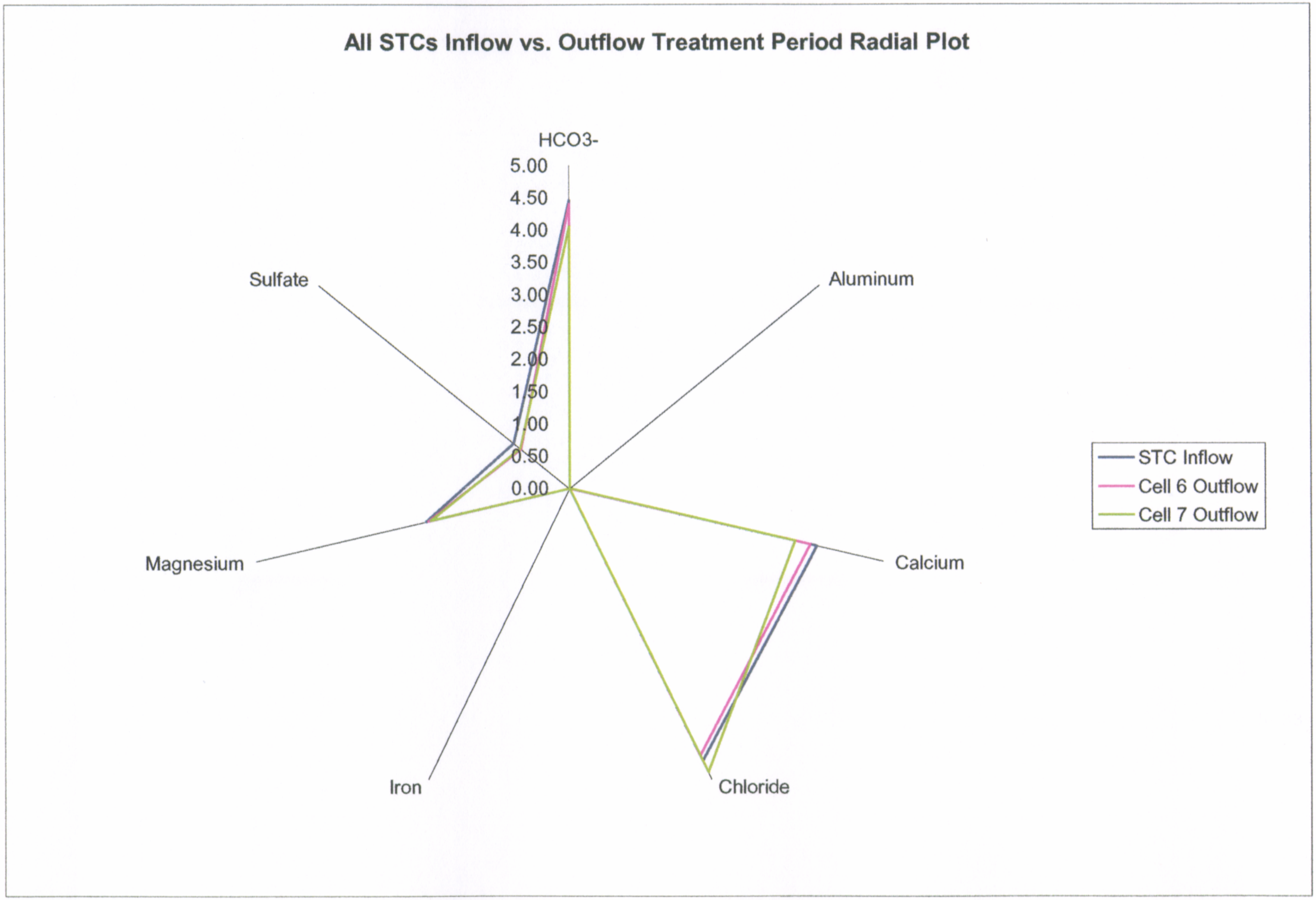


Exhibit 5-29
Radial plot comparing Inflow vs. Outflow in the STCs during the treatment period in meq/L.

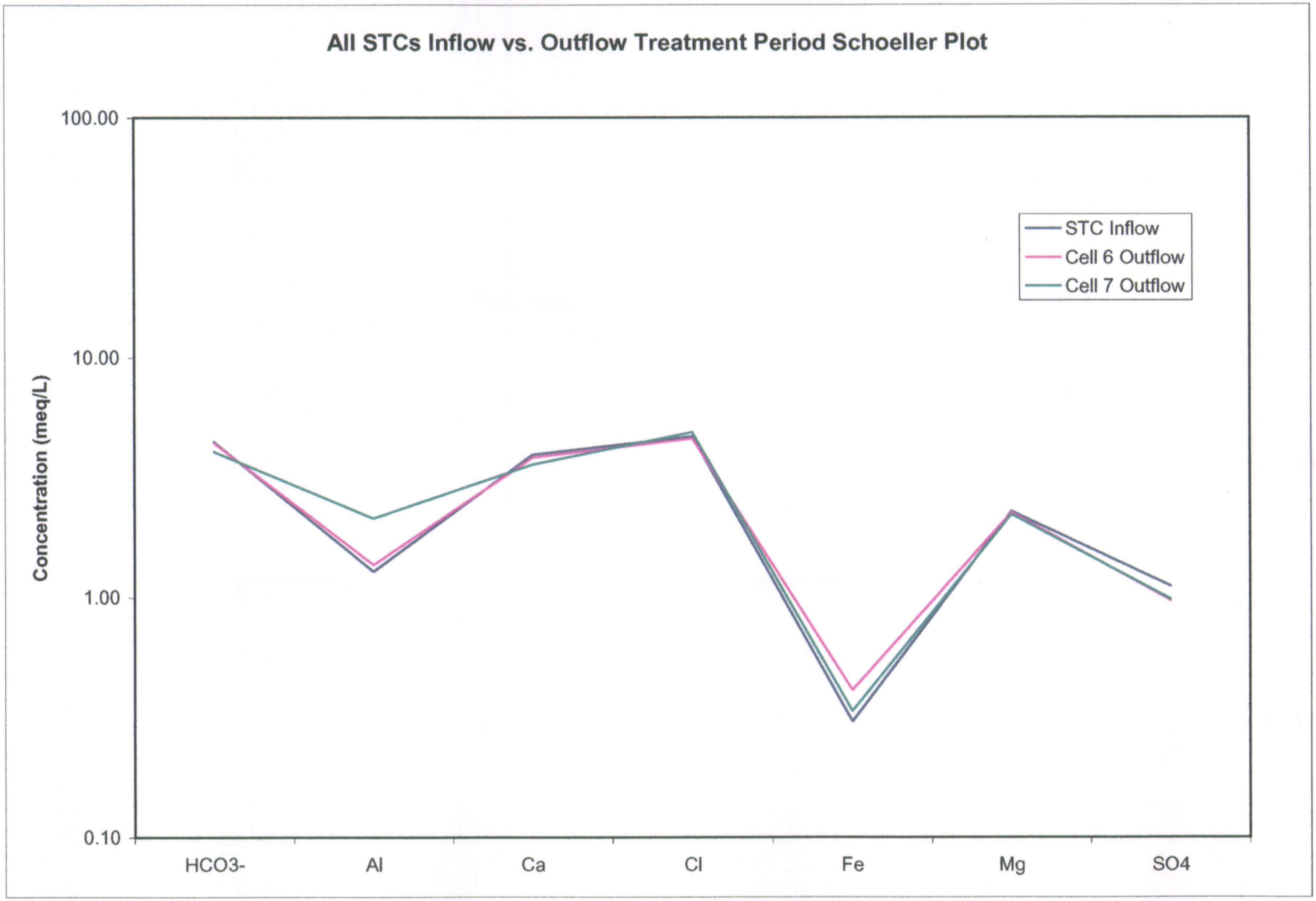


Exhibit 5-30
Schoeller plot comparing Inflow vs. Outflow for the STCs during the treatment period.
Note: Concentrations of Iron and Aluminum are expressed in microeq/L.

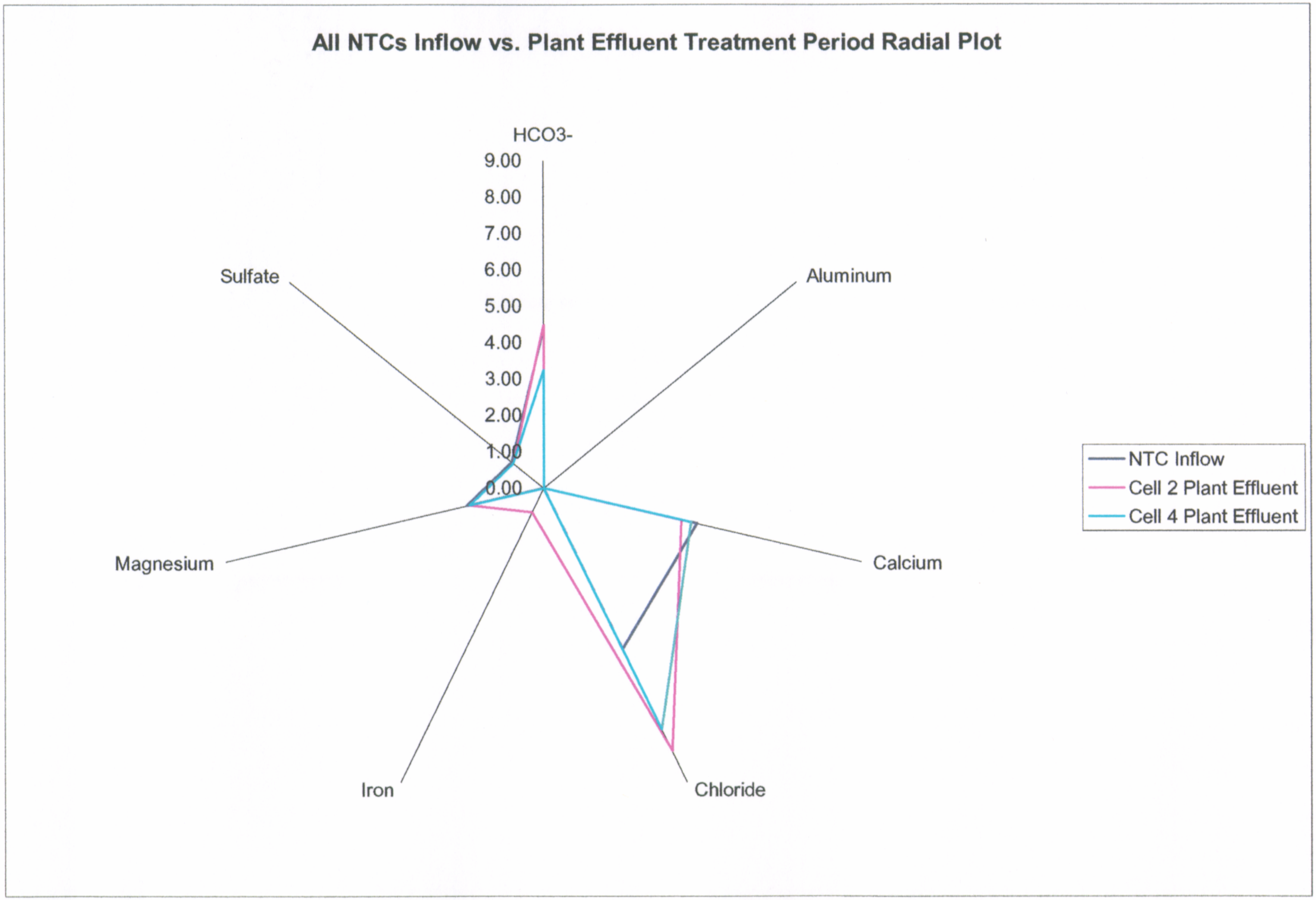


Exhibit 5-31
Radial plot comparing Inflow vs. Plant Effluent in the NTCs during the treatment period in meq/L.

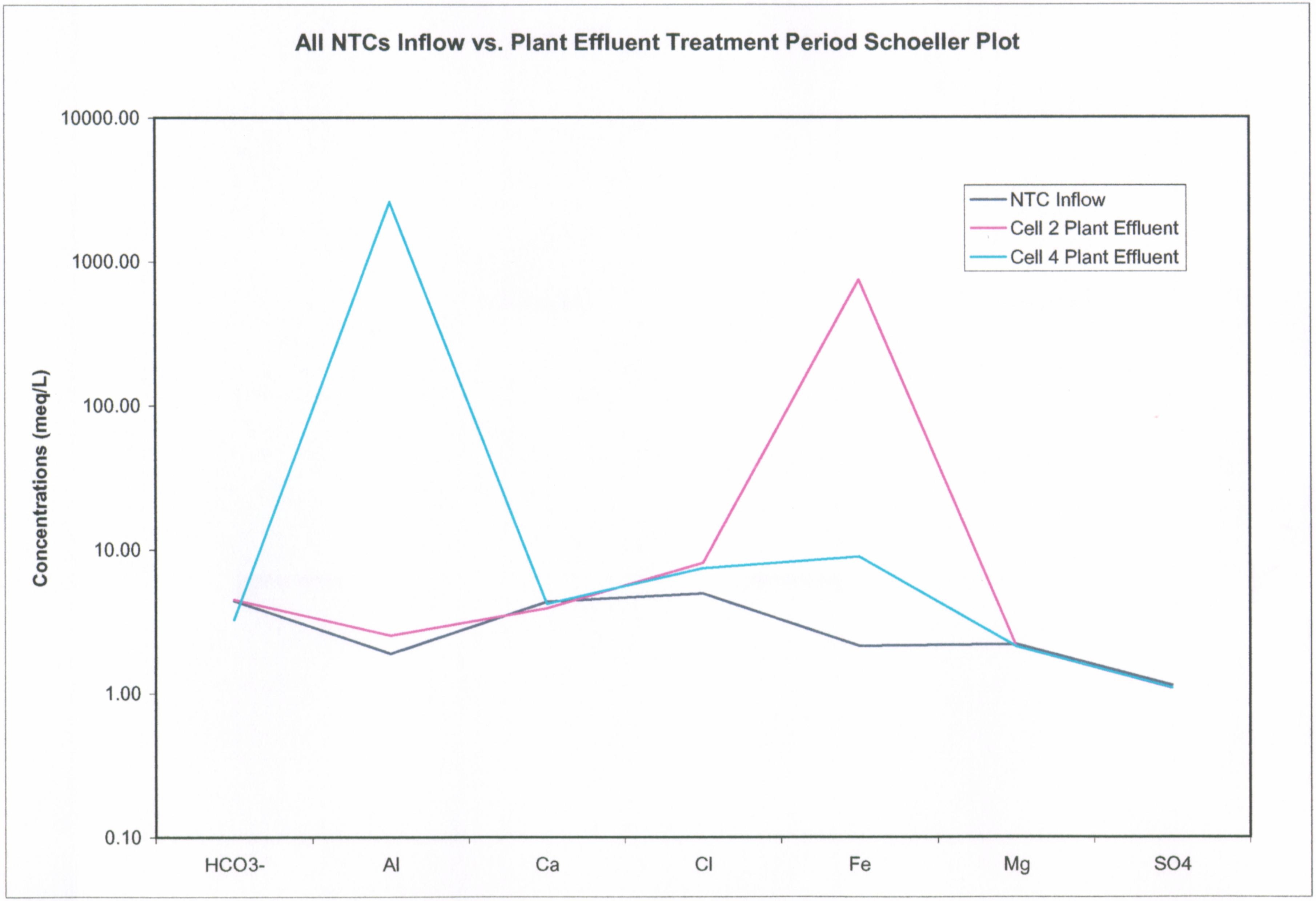


Exhibit 5-32
Schoeller plot comparing Inflow vs. Plant Effluent for the NTCs during the treatment period.
Note: Concentrations of Iron and Aluminum are expressed in microeq/L.

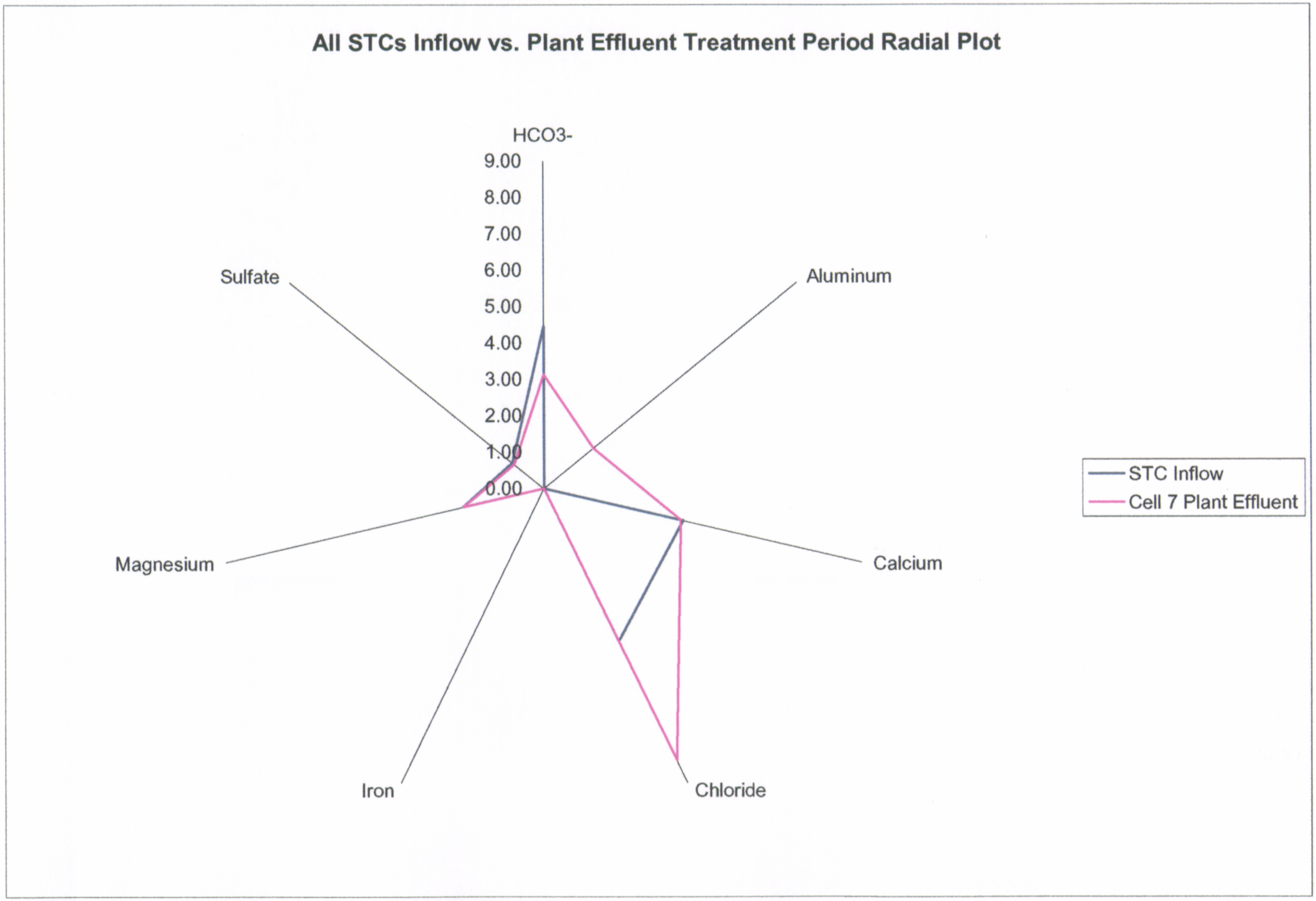


Exhibit 5-33
Radial plot comparing Inflow vs. Plant Effluent in the STCs during the treatment period in meq/L.

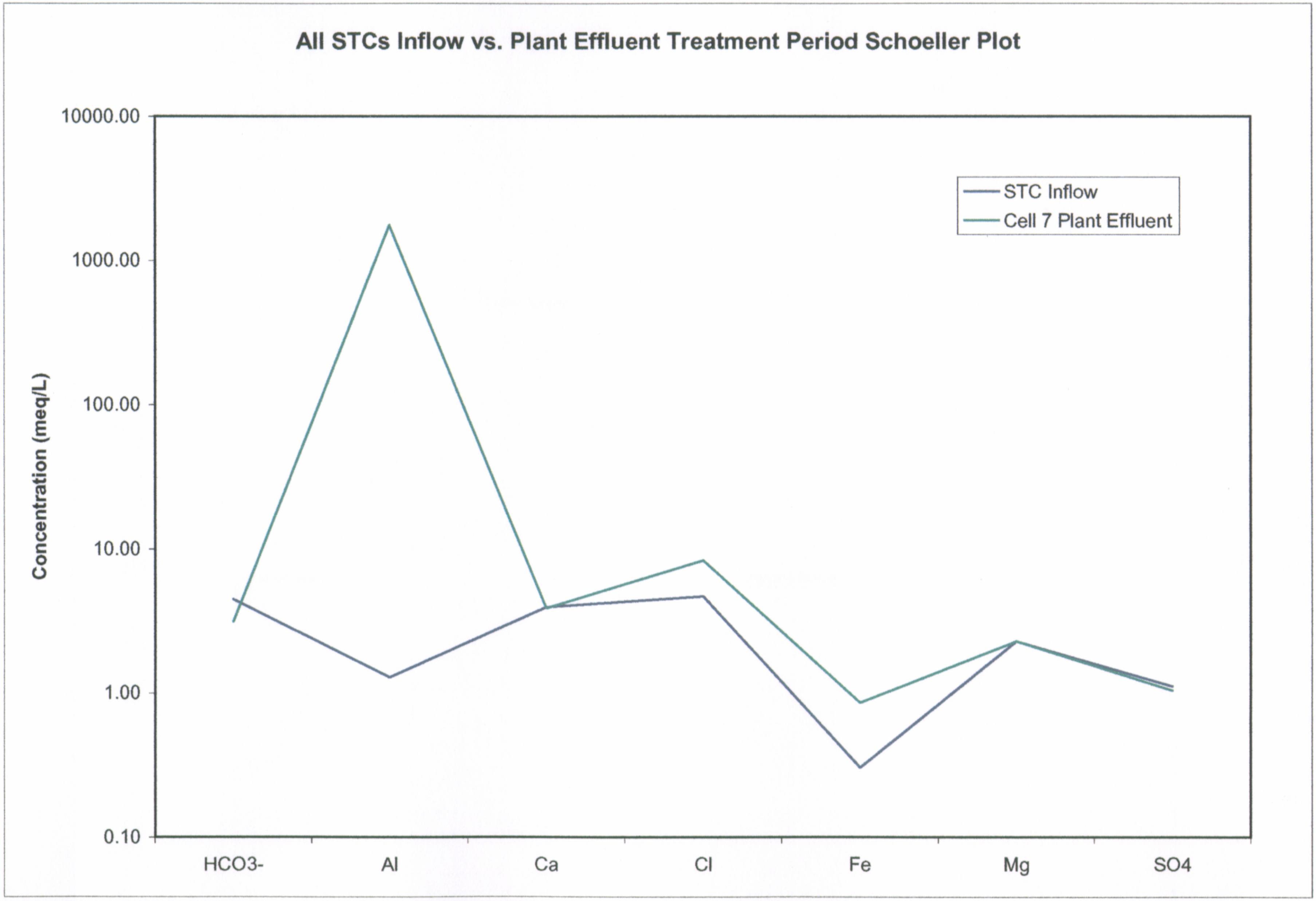


Exhibit 5-34
Schoeller plot comparing Inflow vs. Plant Effluent for the STCs during the treatment period.
Note: Concentrations of Iron and Aluminum are expressed in microeq/L.

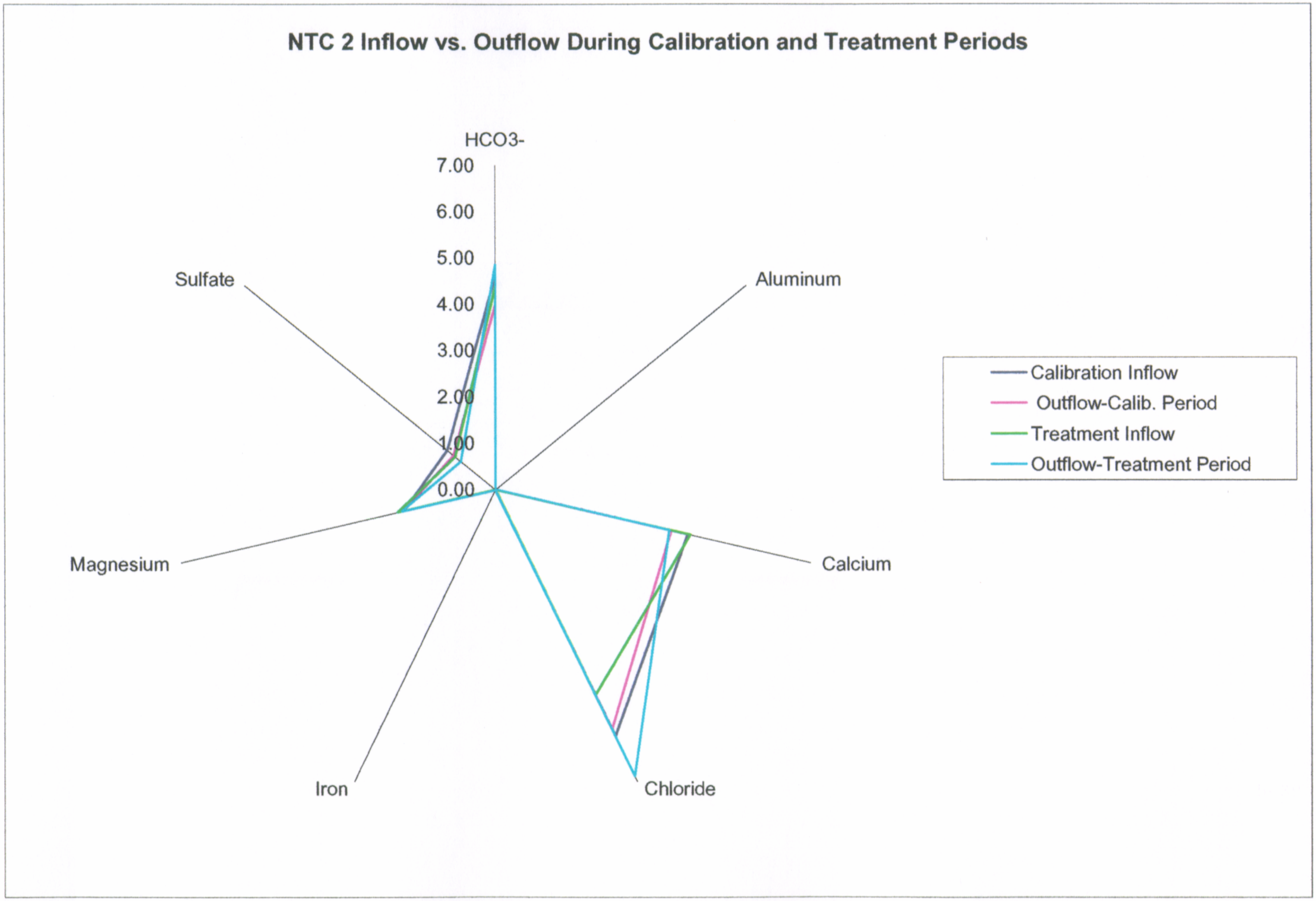


Exhibit 5-35
Radial plot comparing Inflow vs. Outflow for NTC 2 during the calibration and treatment periods in meq/L.

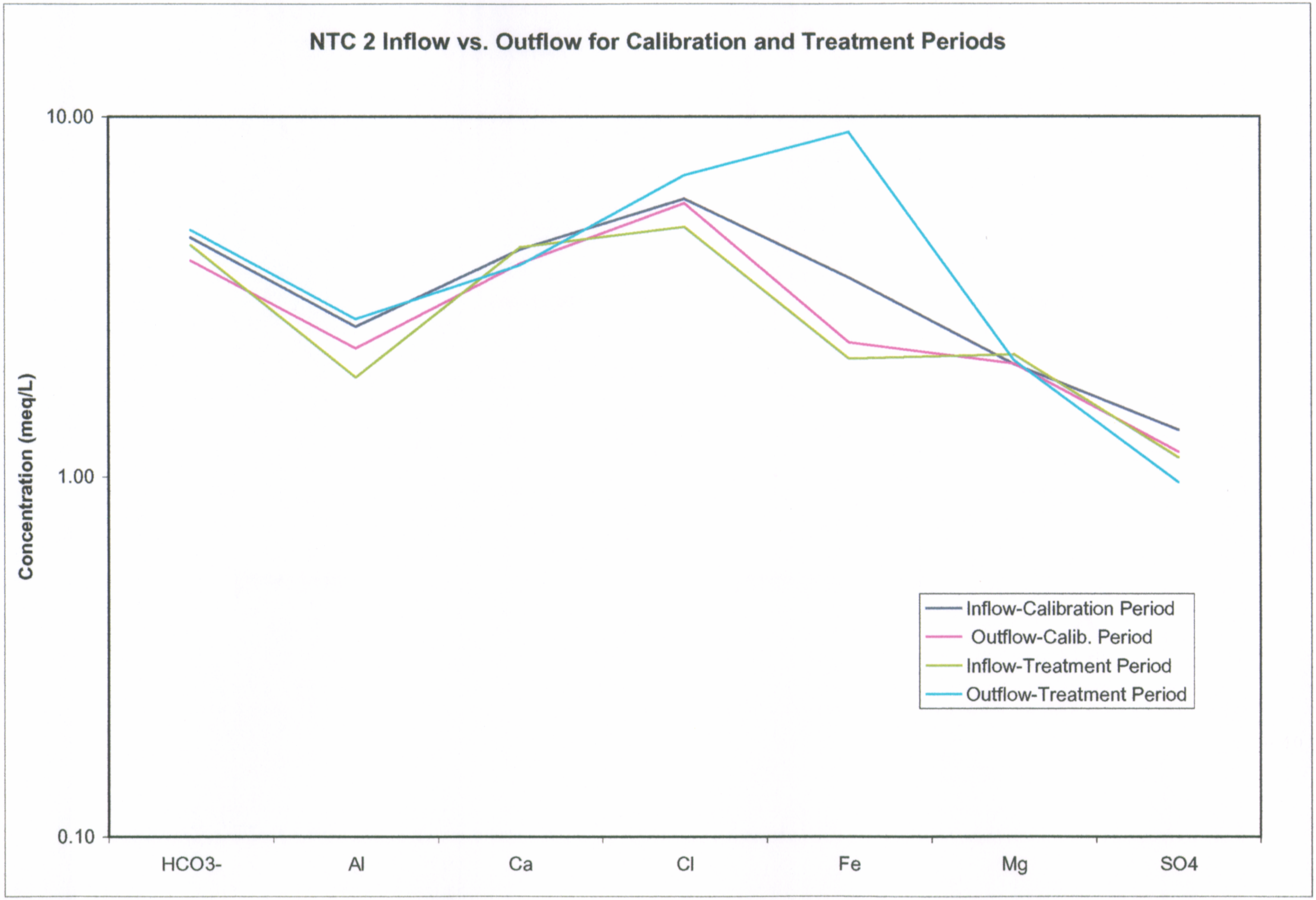


Exhibit 5-36
Schoeller plot comparing Inflow vs. Outflow for NTC 2 during the calibration and treatment periods.
Note: Concentrations of Iron and Aluminum are expressed in microeq/L.

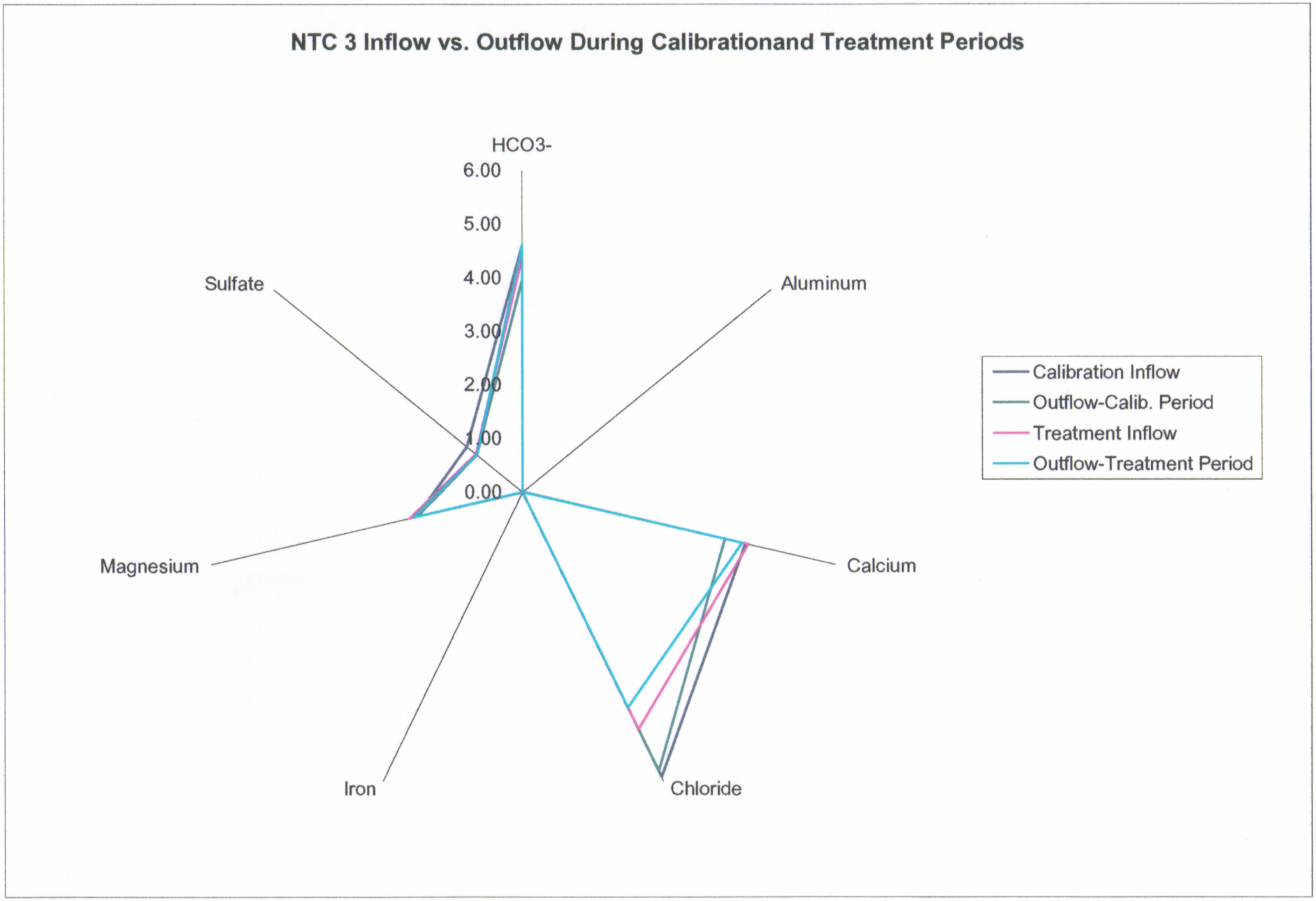


Exhibit 5-37
Radial plot comparing Inflow vs. Outflow for NTC 3 during the calibration and treatment periods in meq/L.

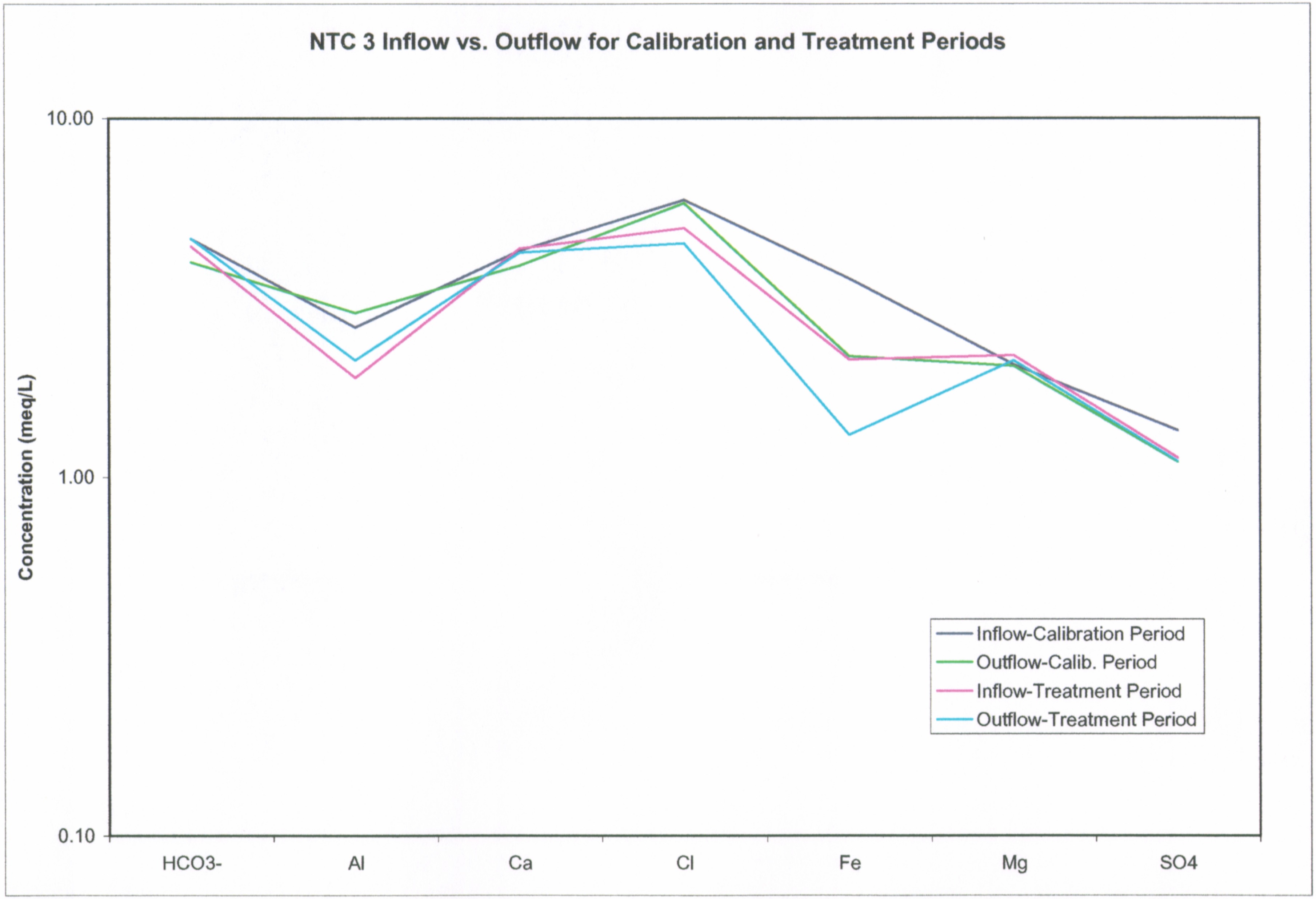


Exhibit 5-38
Schoeller plot comparing Inflow vs. Outflow for NTC 3 during the calibration and treatment periods.
Note: Iron and Aluminum concentrations are expressed in (microeq/L).

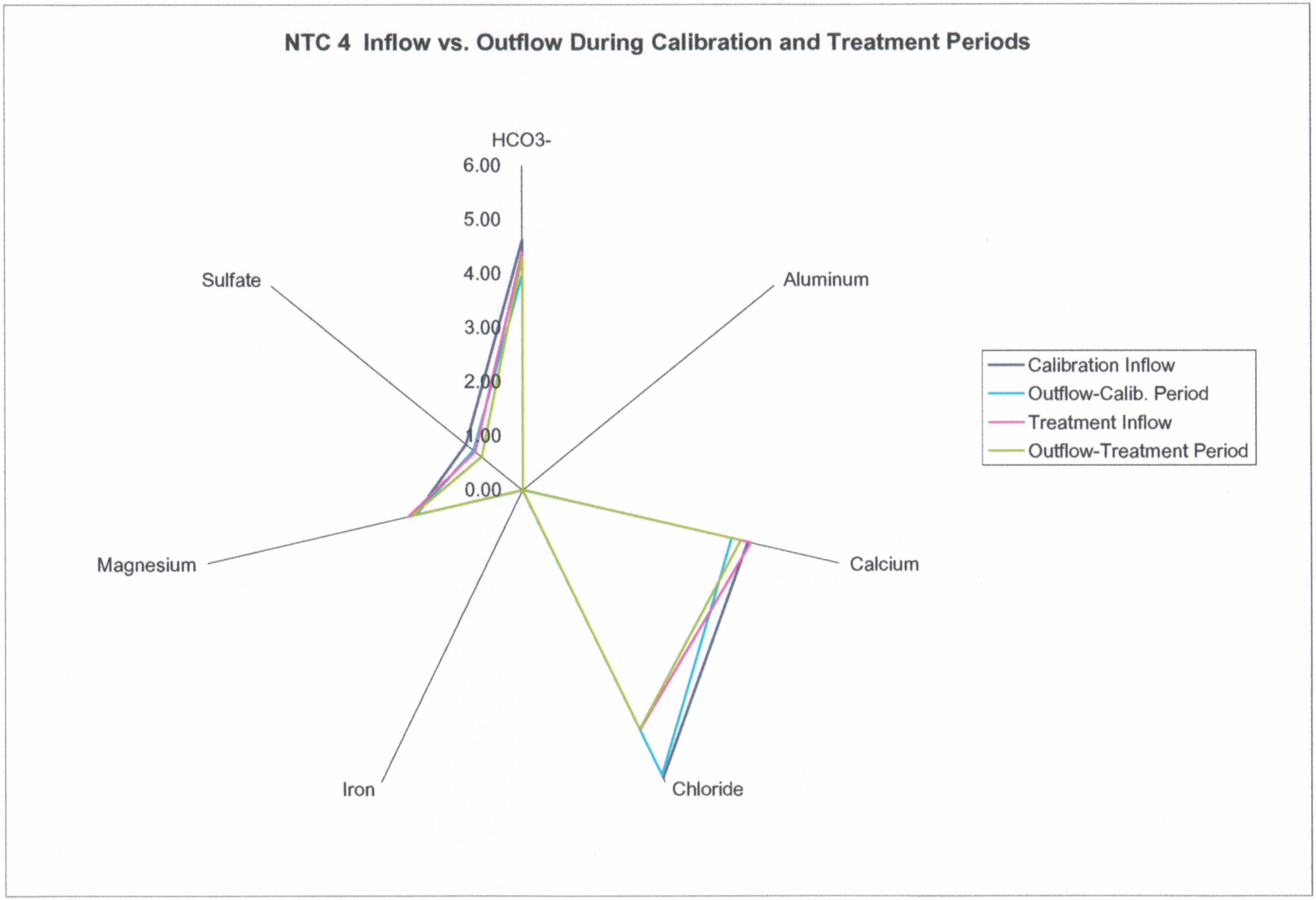


Exhibit 5-39
Radial plot comparing Inflow vs. Outflow for NTC 4 during the calibration and treatment periods in meq/L.

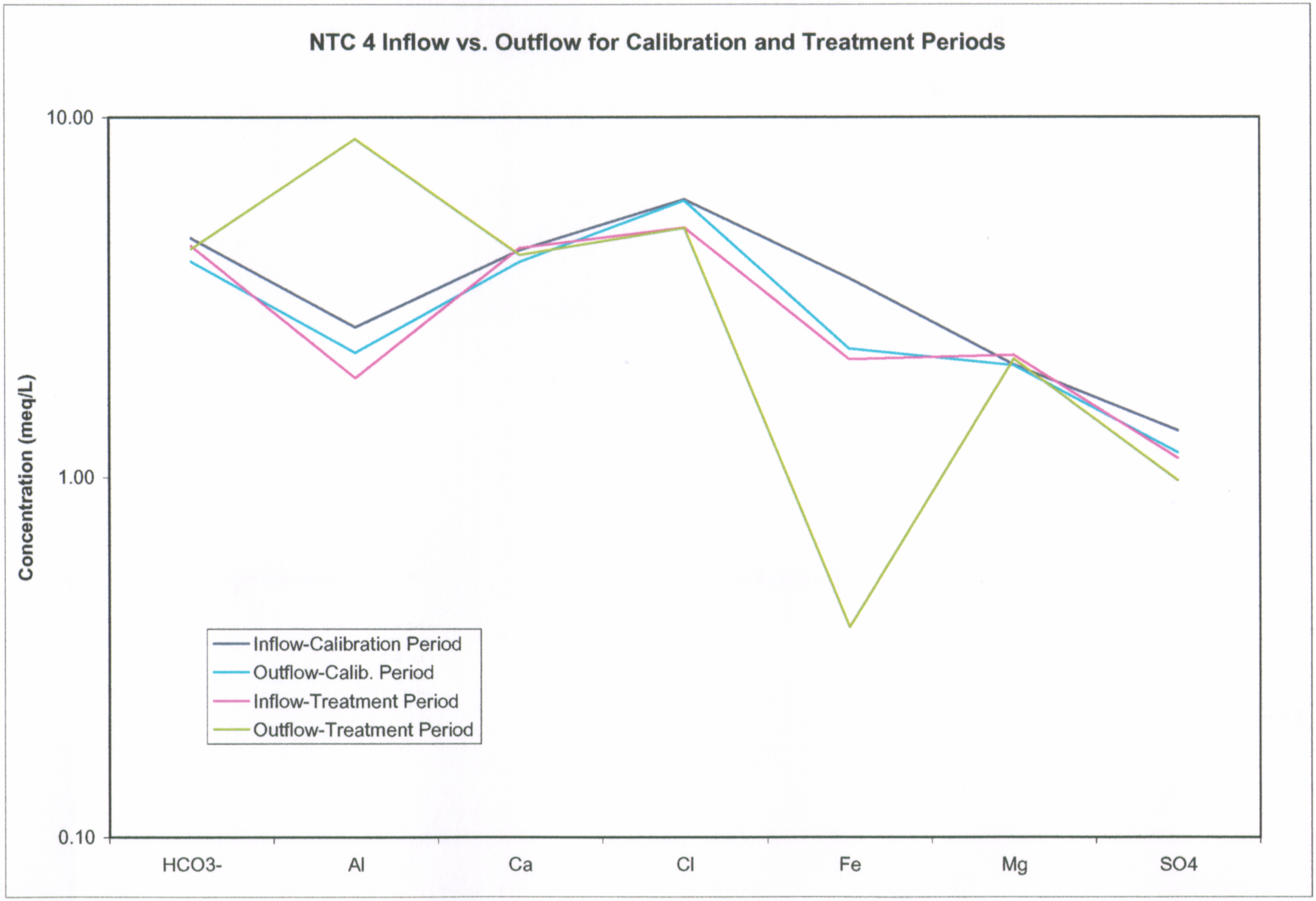


Exhibit 5-40
Schoeller plot comparing Inflow vs. Outflow for NTC 4 during the calibration and treatment periods.
Note: Iron and Aluminum concentrations are expressed in microeq/L.

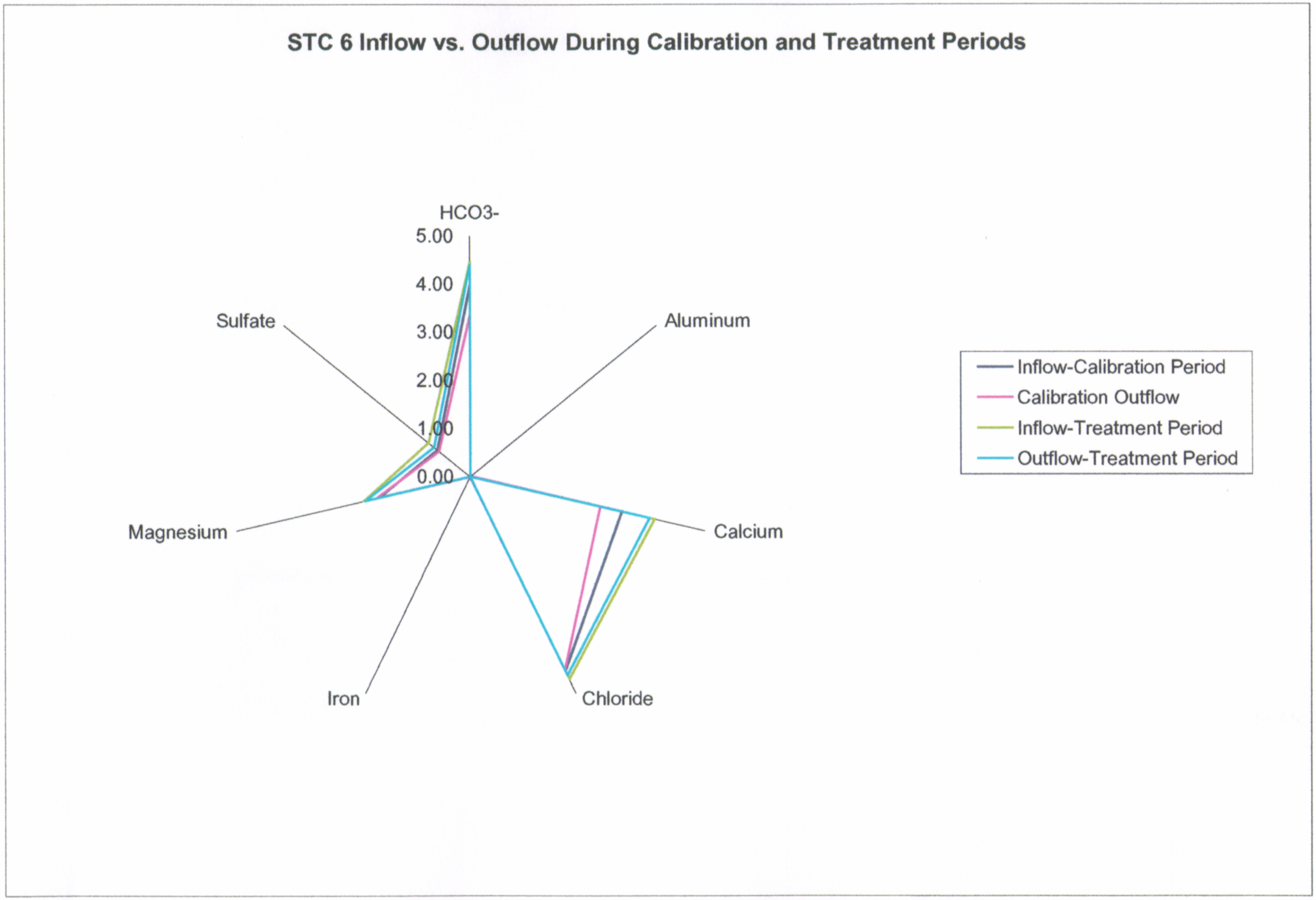


Exhibit 5-41
Radial plot comparing Inflow vs. Outflow for STC 6 during the calibration and treatment periods in meq/L.

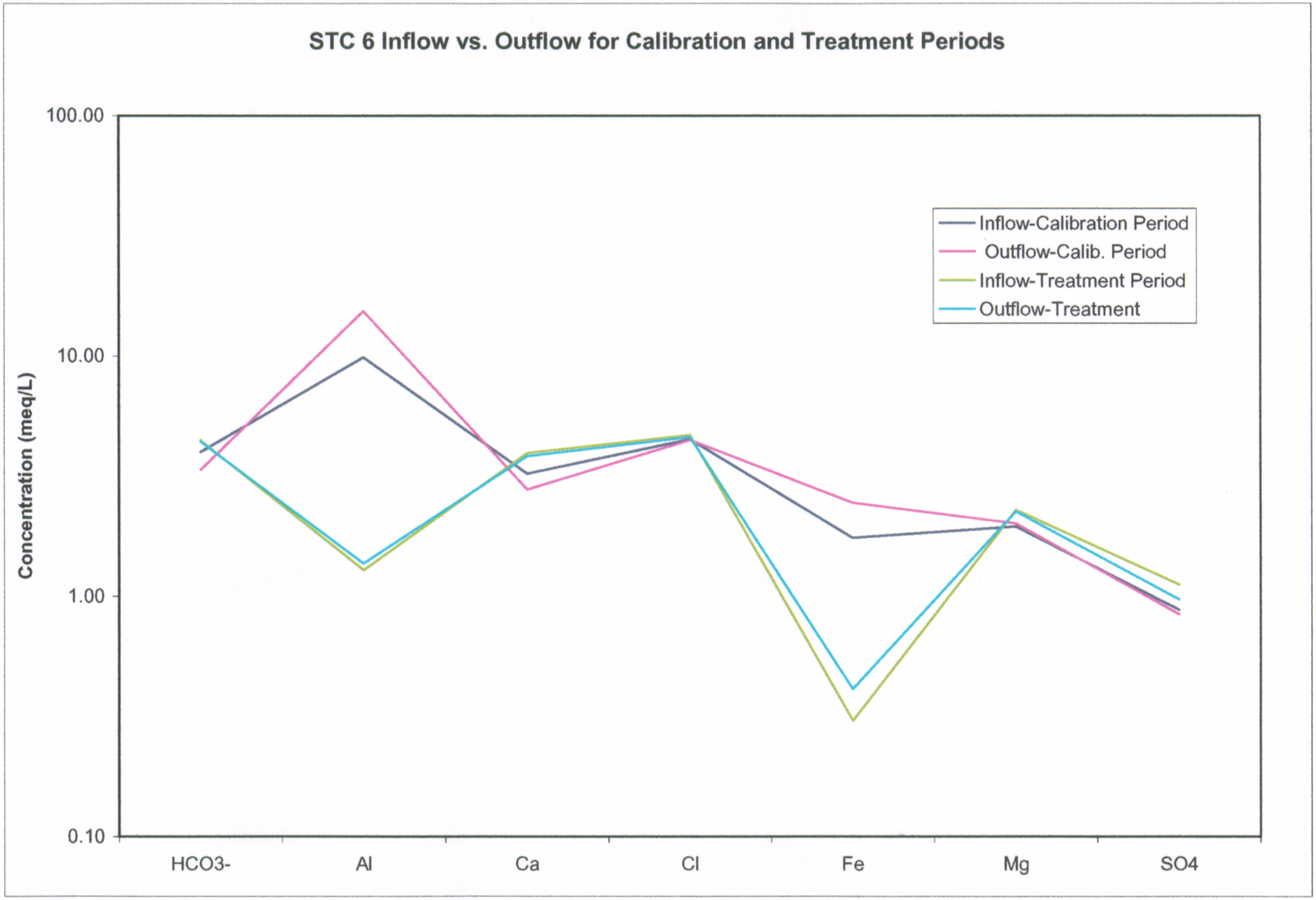


Exhibit 5-42
Schoeller plot comparing Inflow vs. Outflow for STC 6 during the calibration and treatment periods.
Note: Concentrations of Iron and Aluminum are expressed in microeq/L.

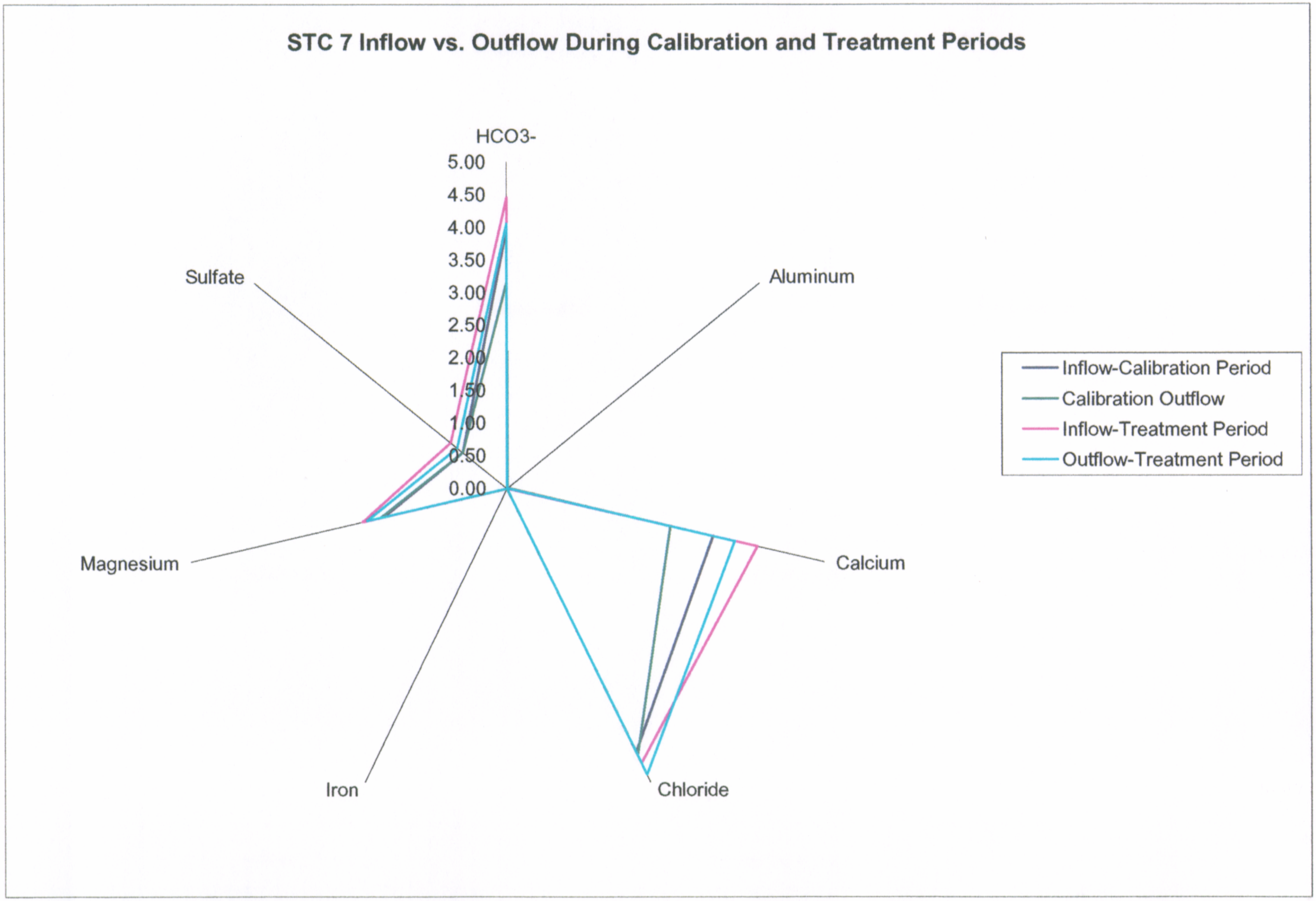


Exhibit 5-43
Radial plot comparing Inflow vs. Outflow for STC 6 during the calibration and treatment periods in meq/L.

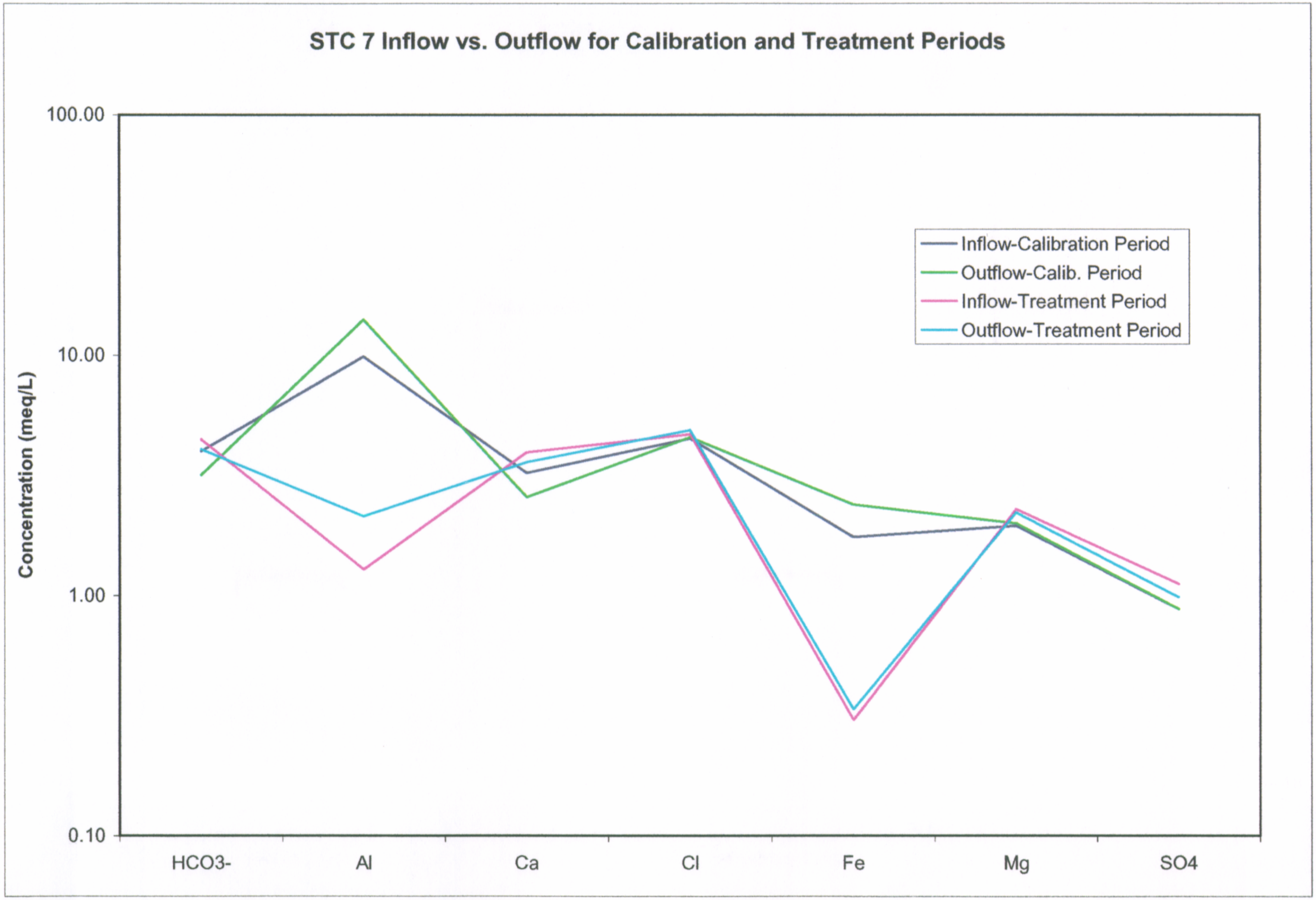


Exhibit 5-44
Schoeller plot comparing Inflow vs. Outflow for STC 7during the calibration and treatment periods.
Note: Iron and Aluminum concentrations expressed in microeq/L.

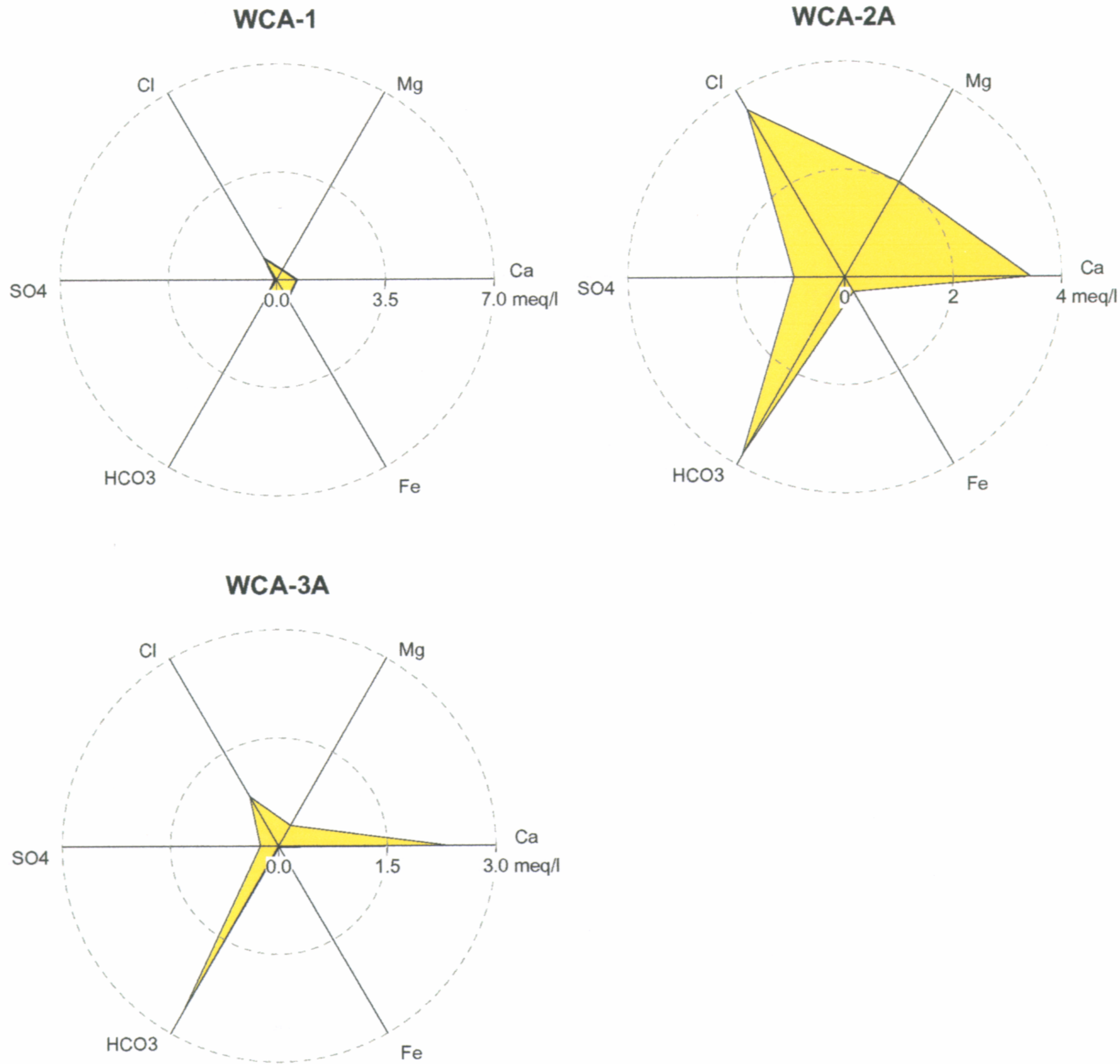


Exhibit 5-45 Radial plots showing the chemical composition of the Water Conservation Areas.

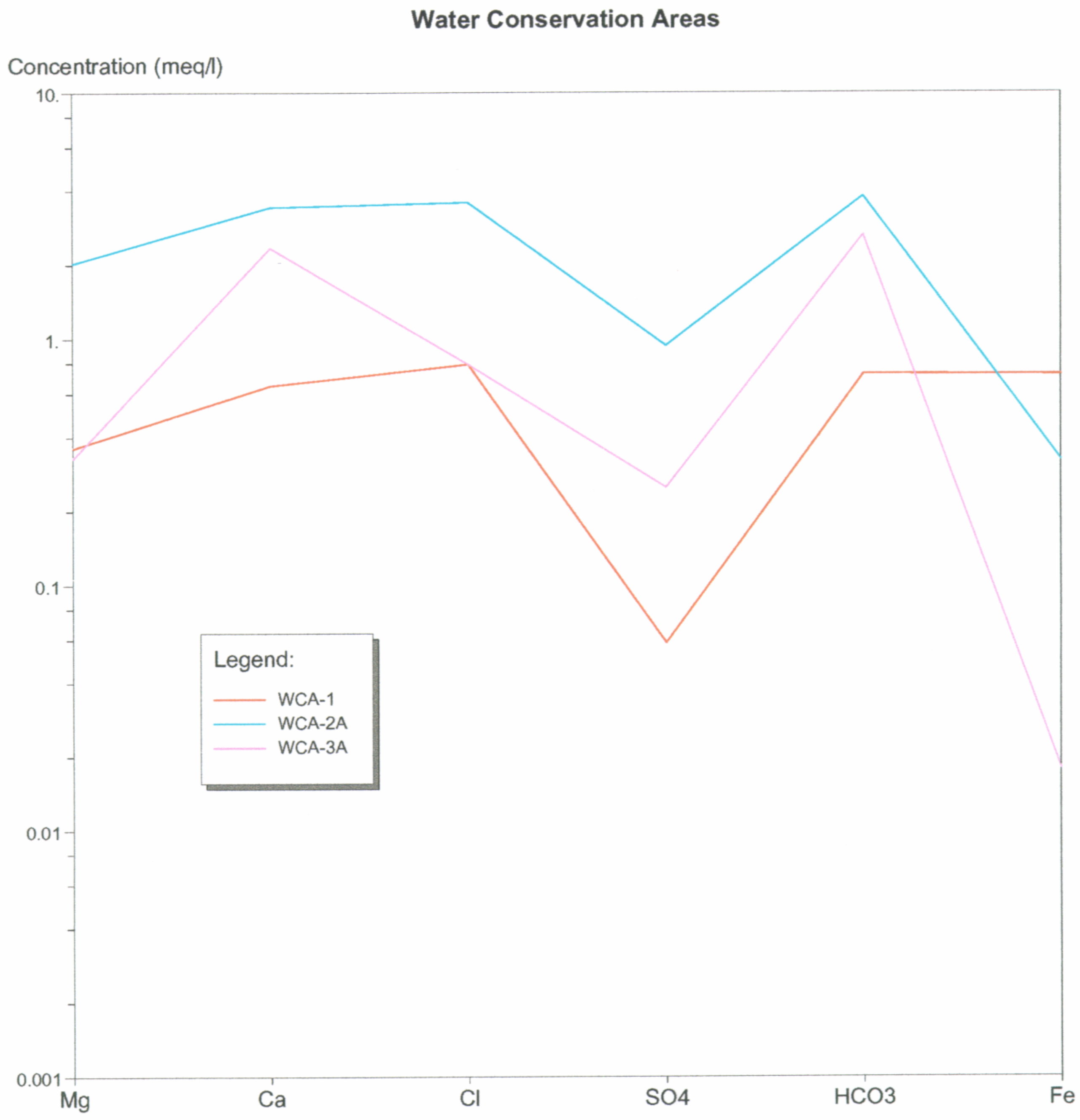
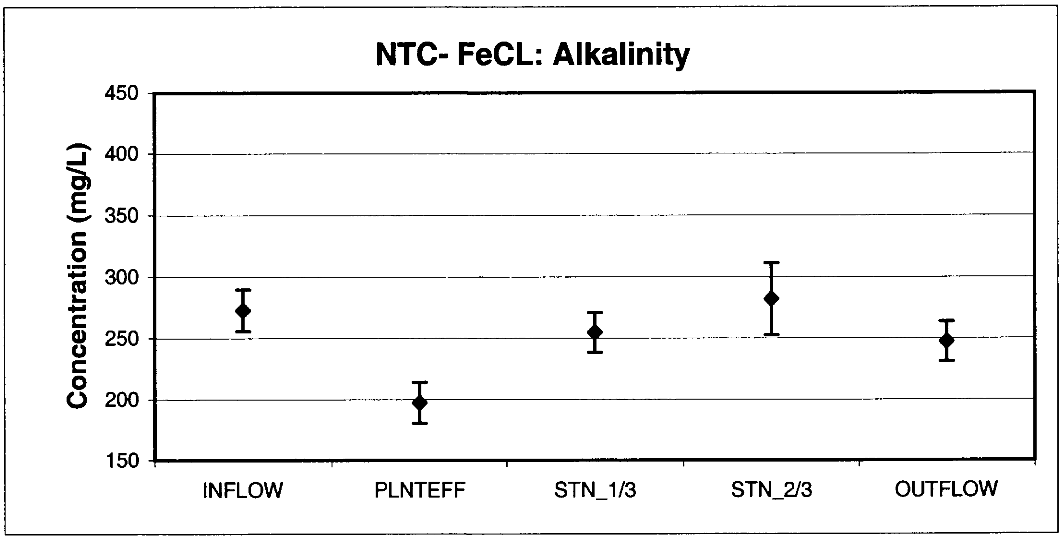
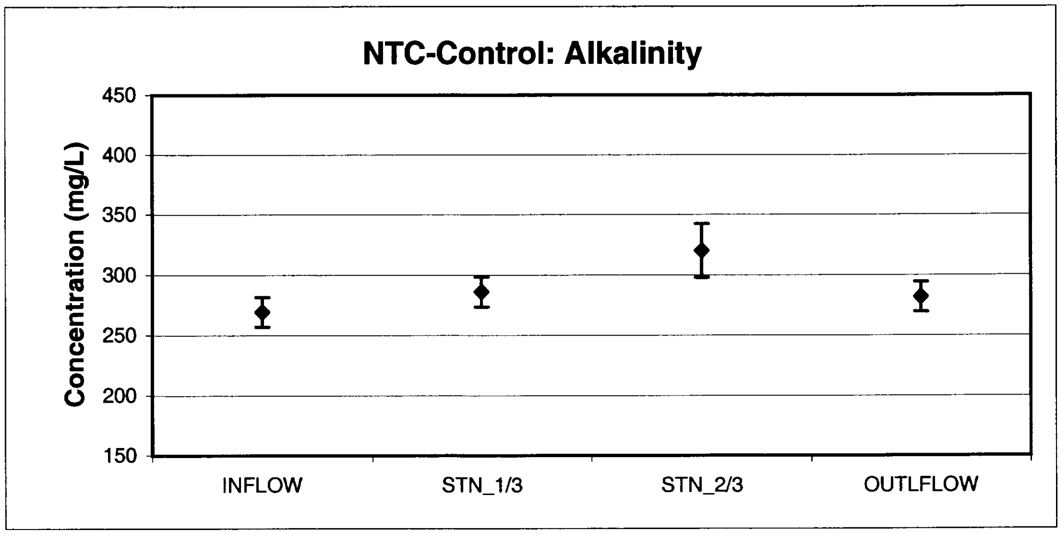


Exhibit 5-46 Schoeller plots showing the chemical composition of the Water Conservation Areas.





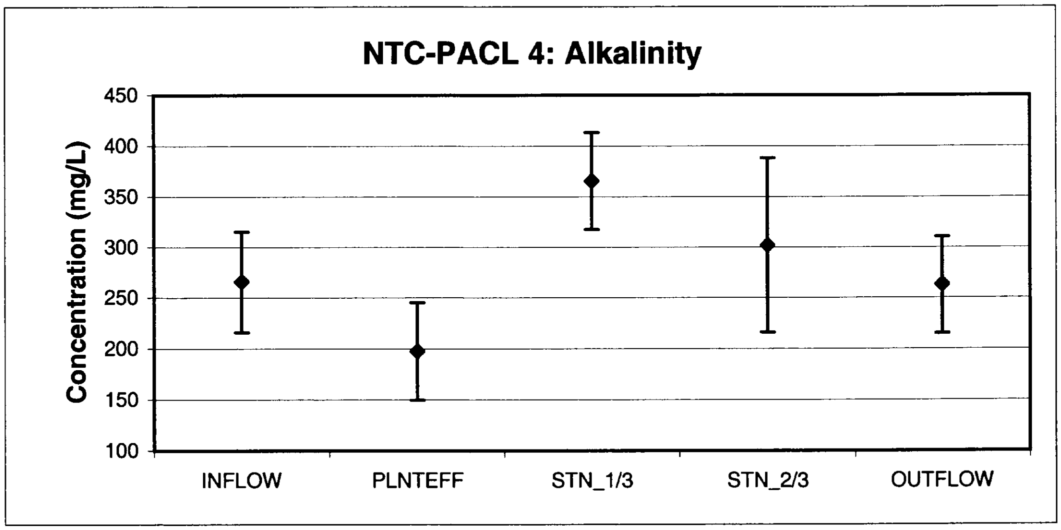
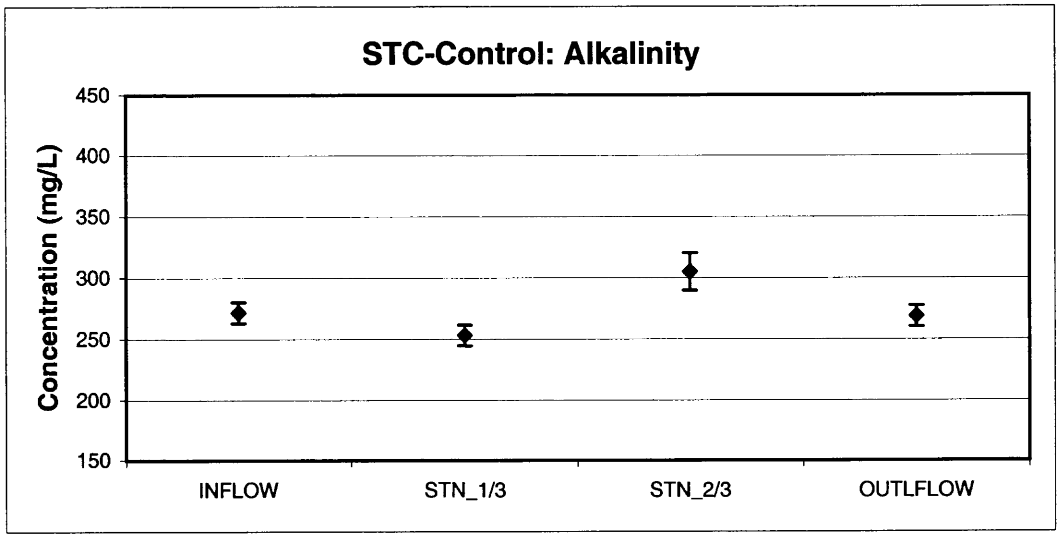


Exhibit 5-47
NTC standard error plots for alkalinity during the treatment period.



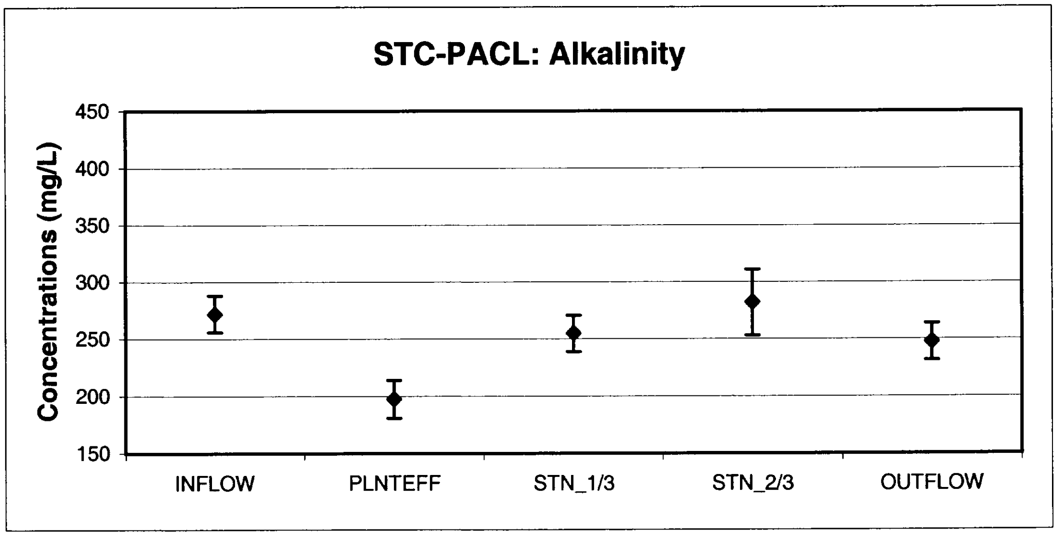
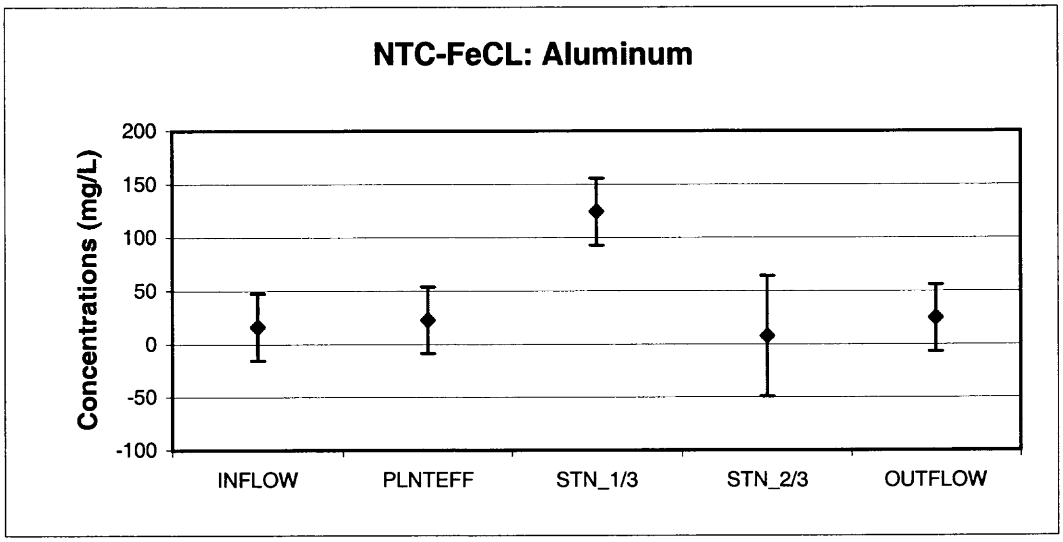
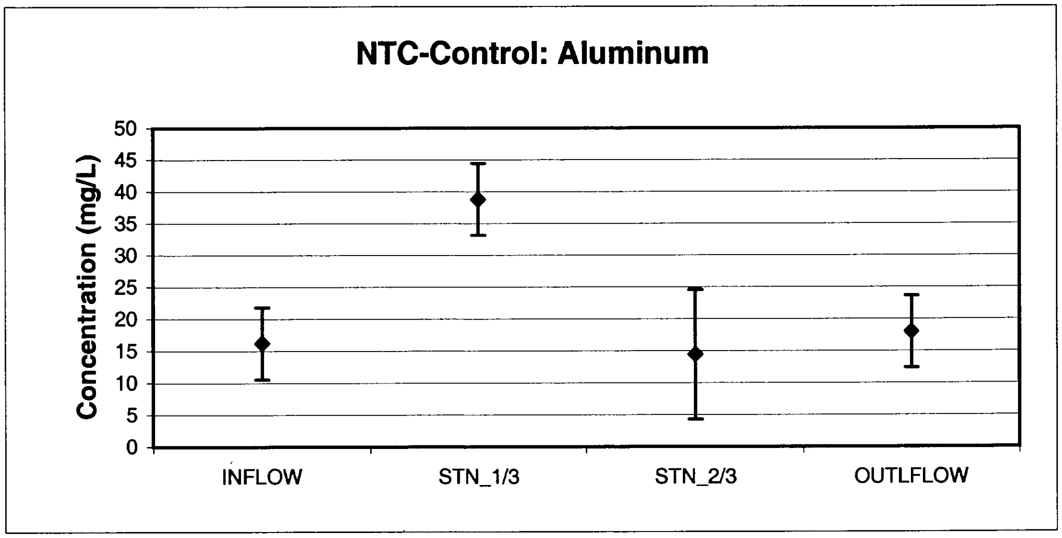


Exhibit 5-48
STC standard error plots for alkalinity during the treatment period.





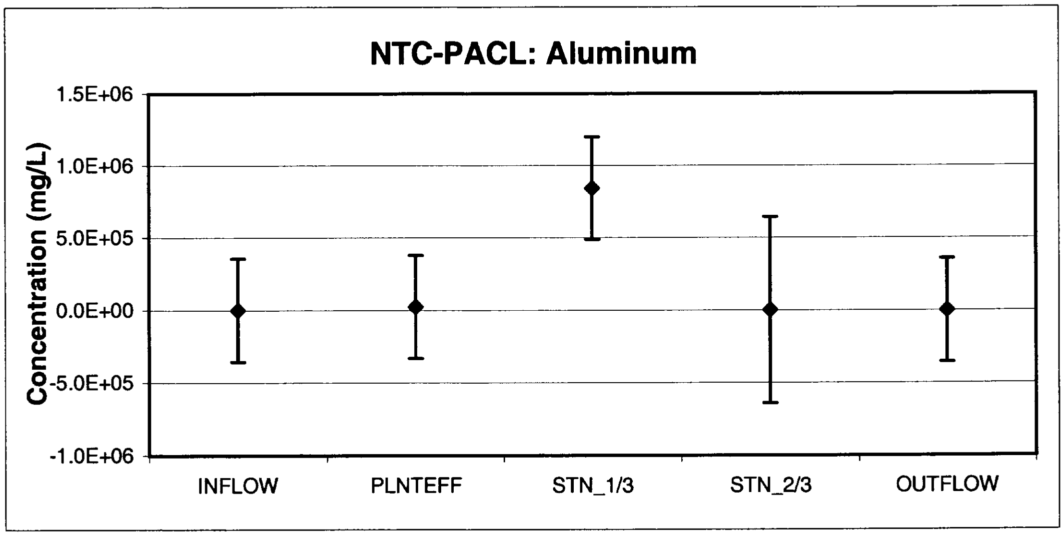
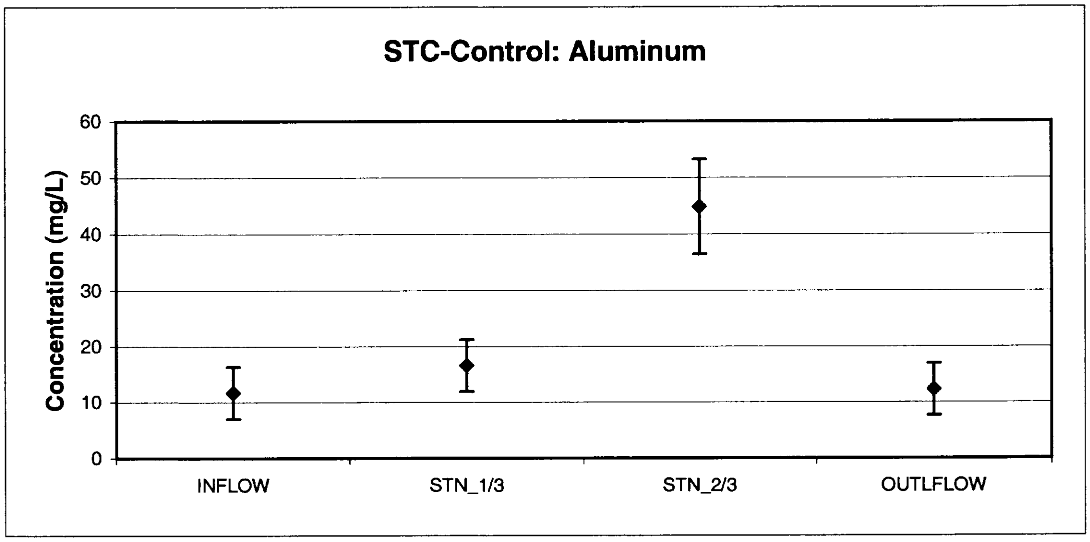


Exhibit 5-49
NTC standard error plots for aluminum for treatment period.



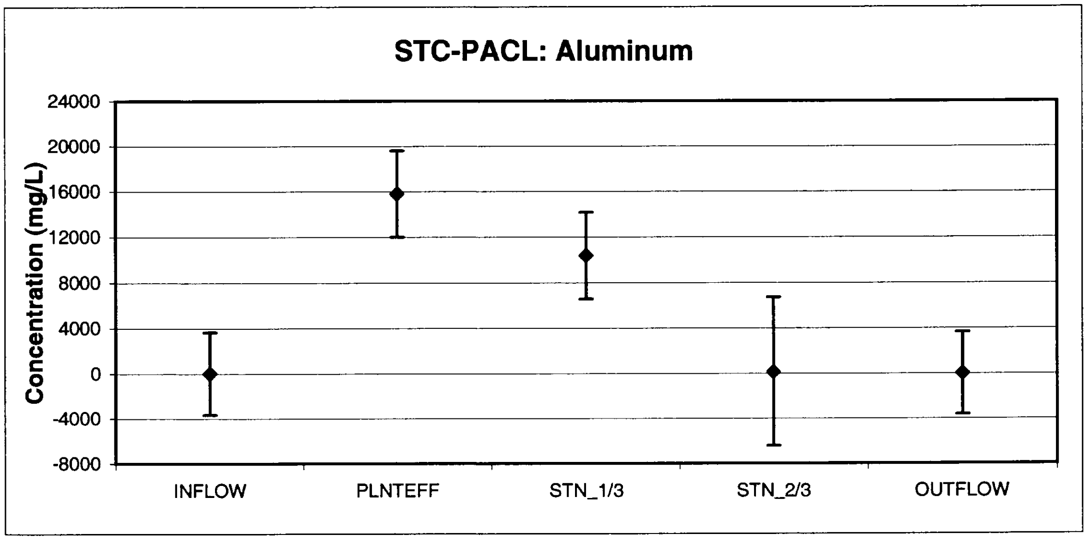
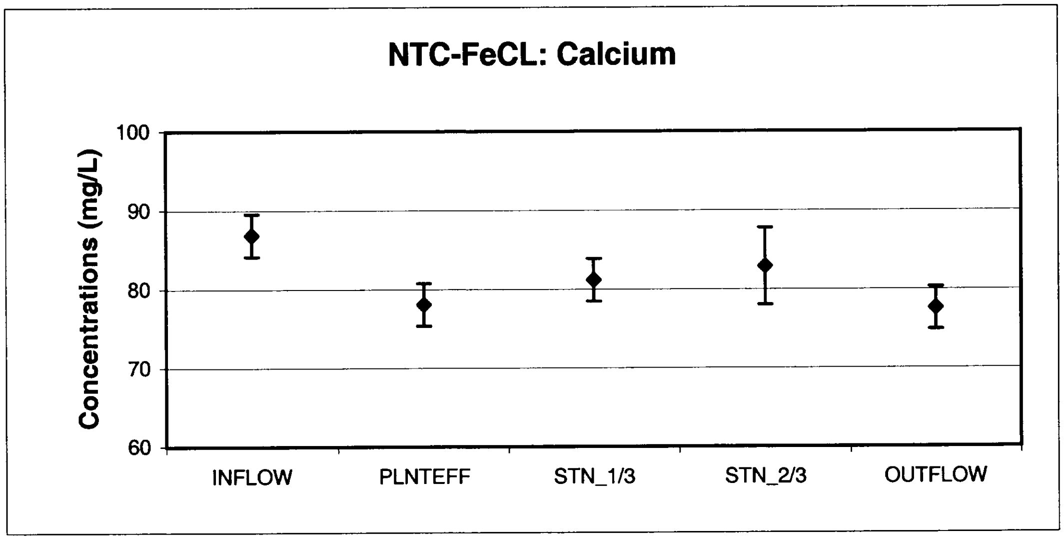
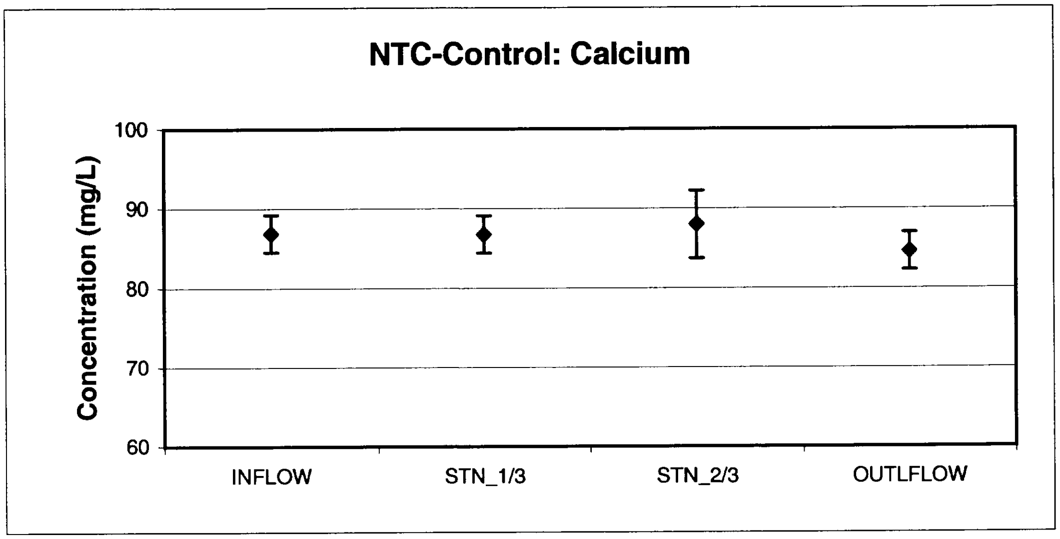


Exhibit 5-50
STC standard error plots for aluminum for treatment period.





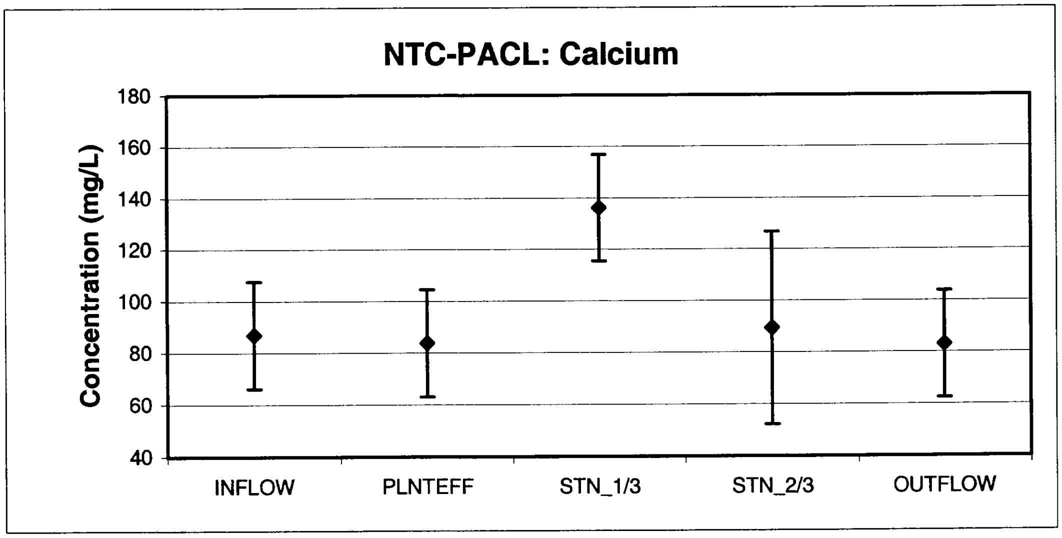
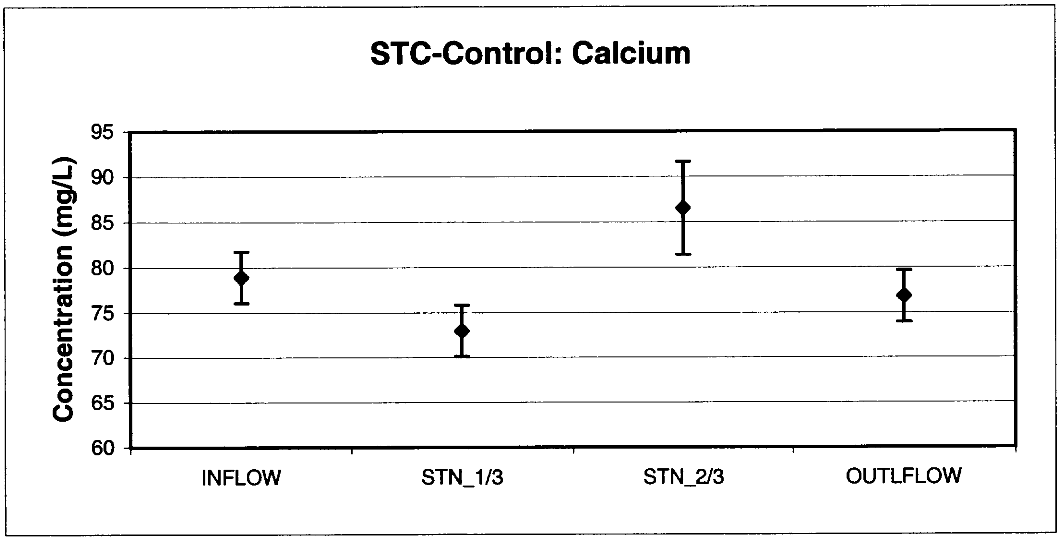


Exhibit 5-51
NTC standard error plots for calcium for treatment period.



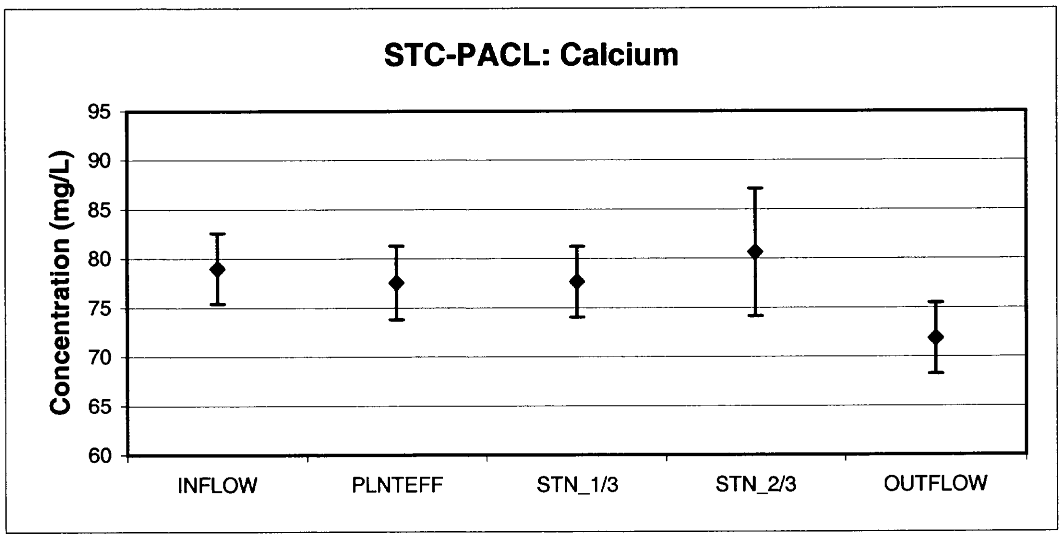
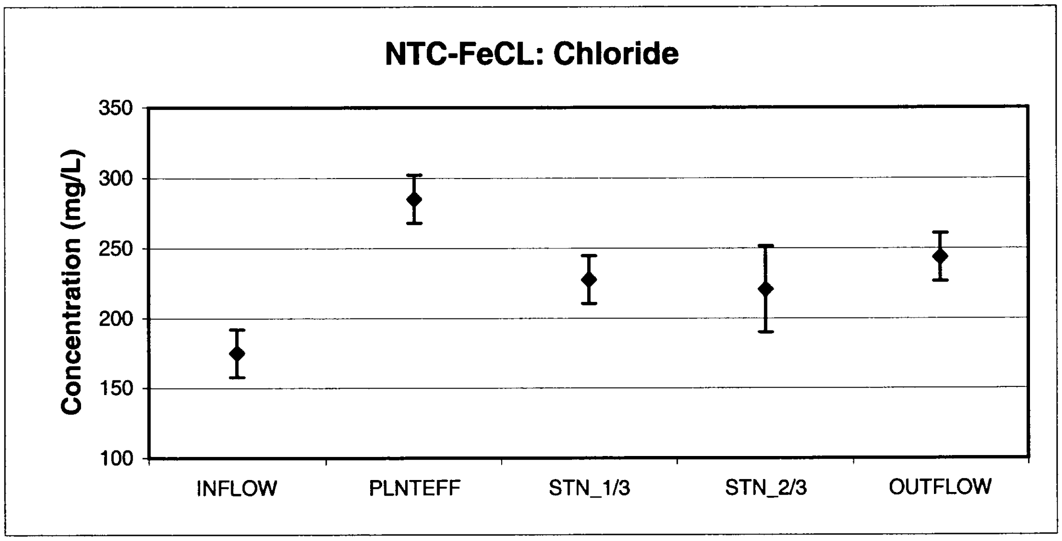
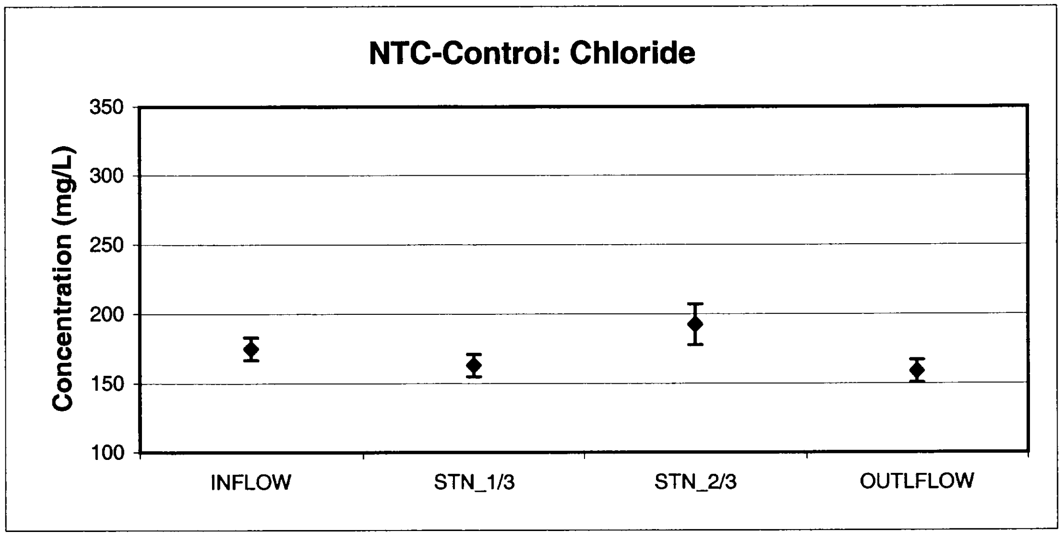


Exhibit 5-52
STC standard error plots for calcium for treatment period.





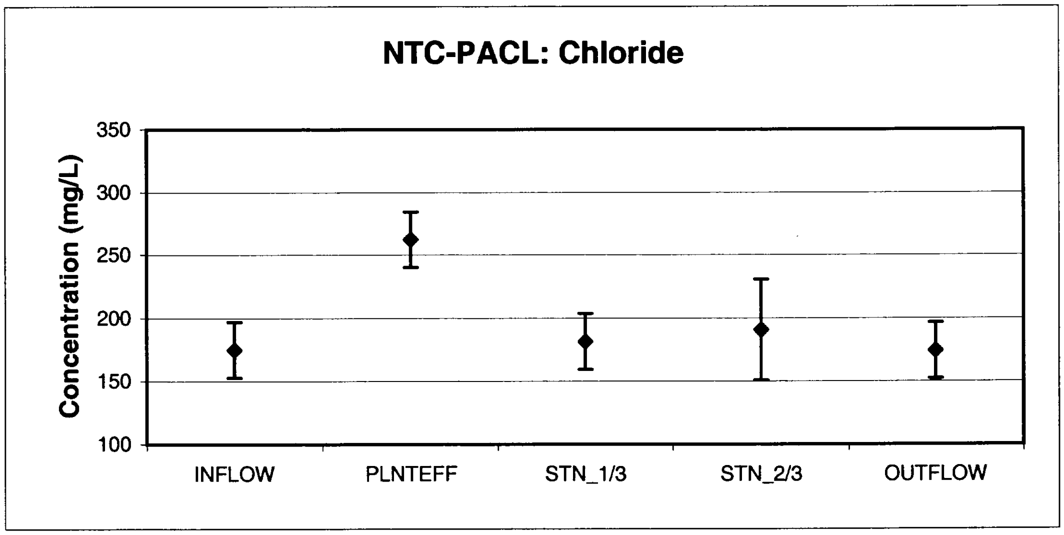
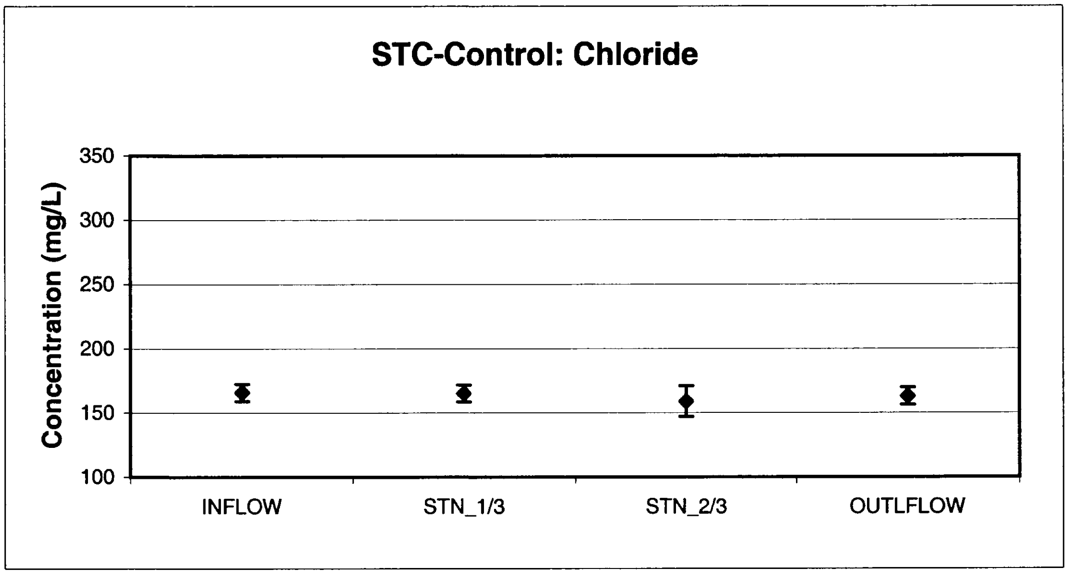


Exhibit 5-53
NTC standard error plot for chloride for treatment period.



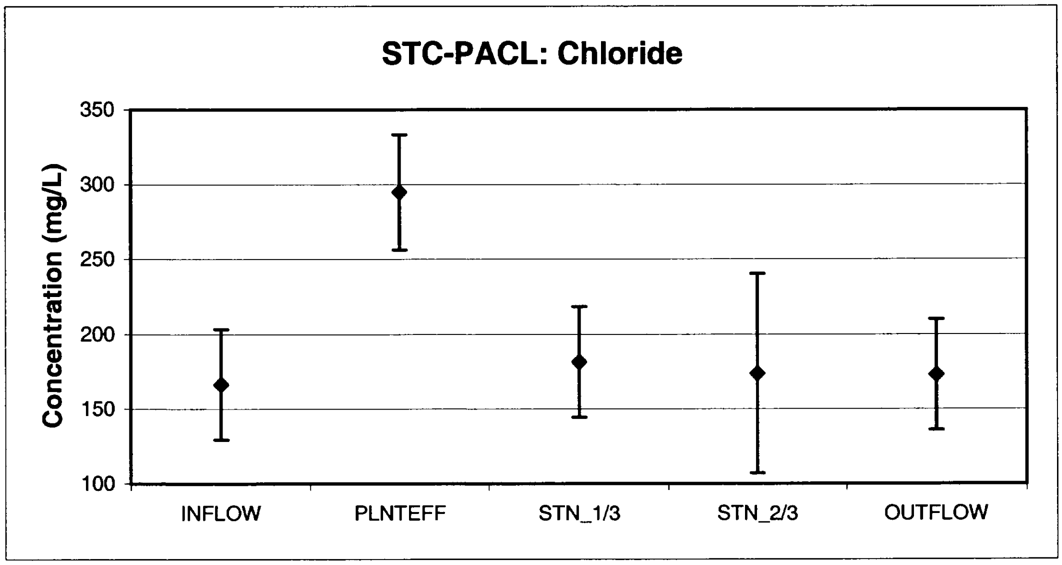
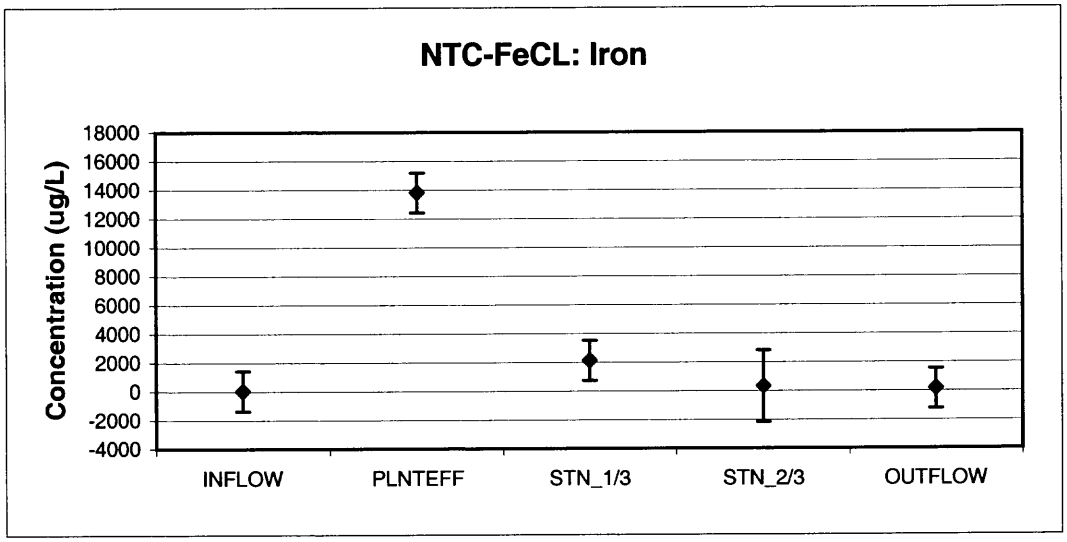
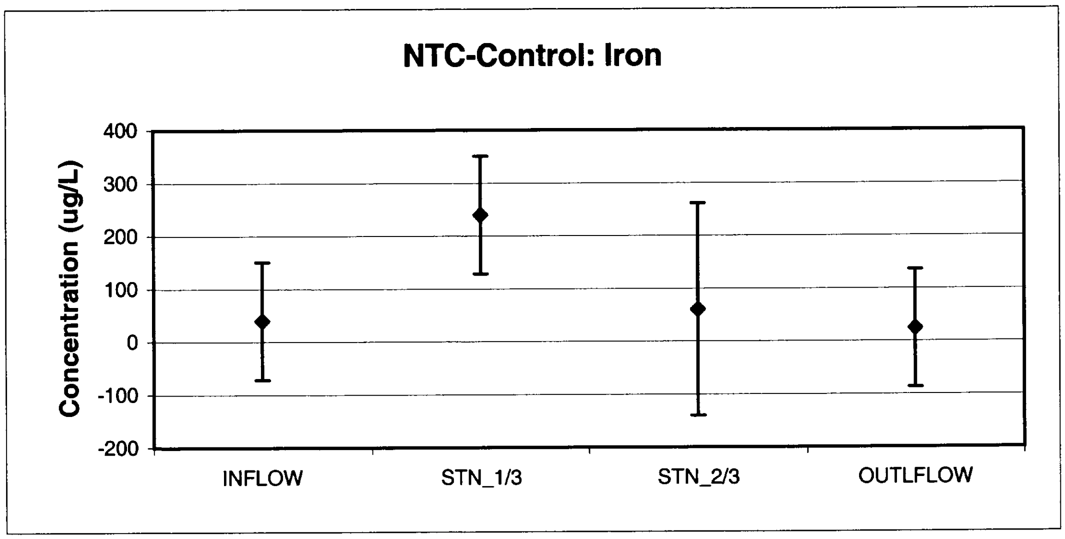


Exhibit 5-54
STC standard error plot for chloride for treatment period.





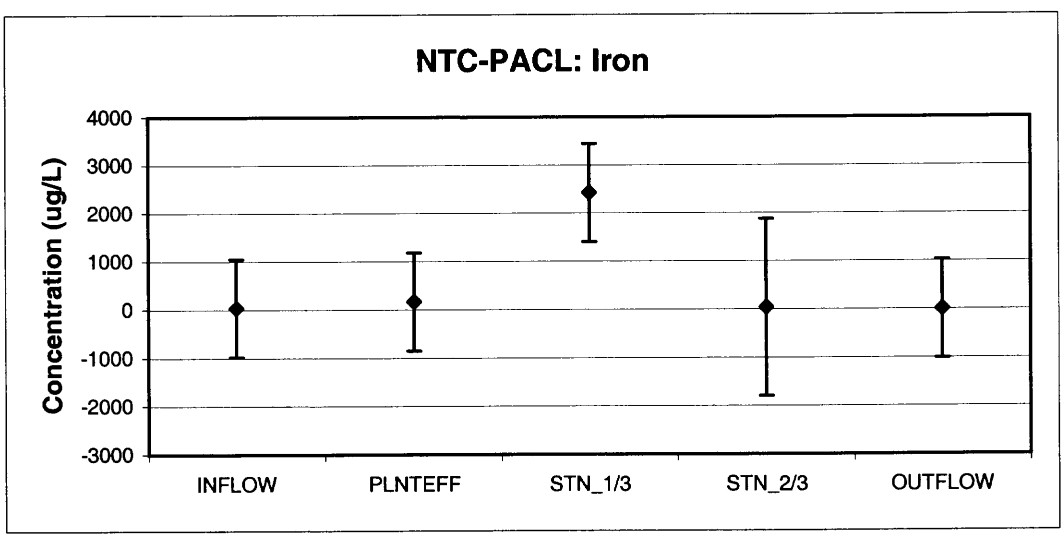
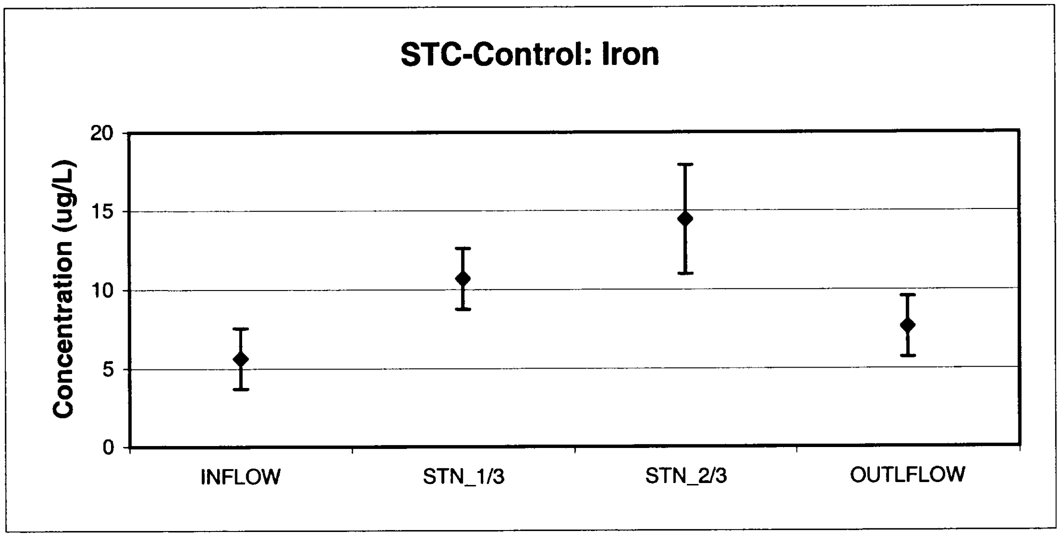


Exhibit 5-55
NTC standard error plots of iron for treatment period.



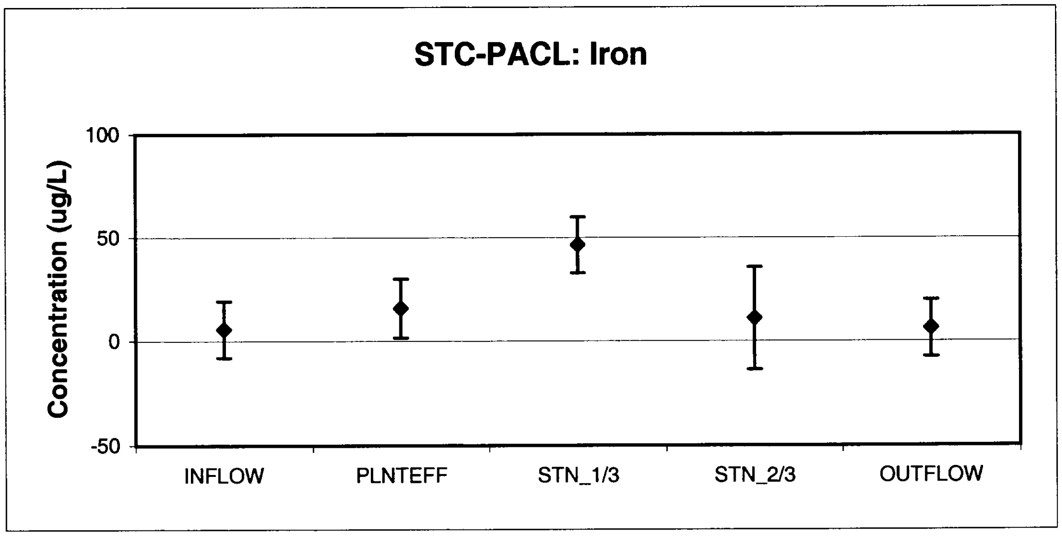
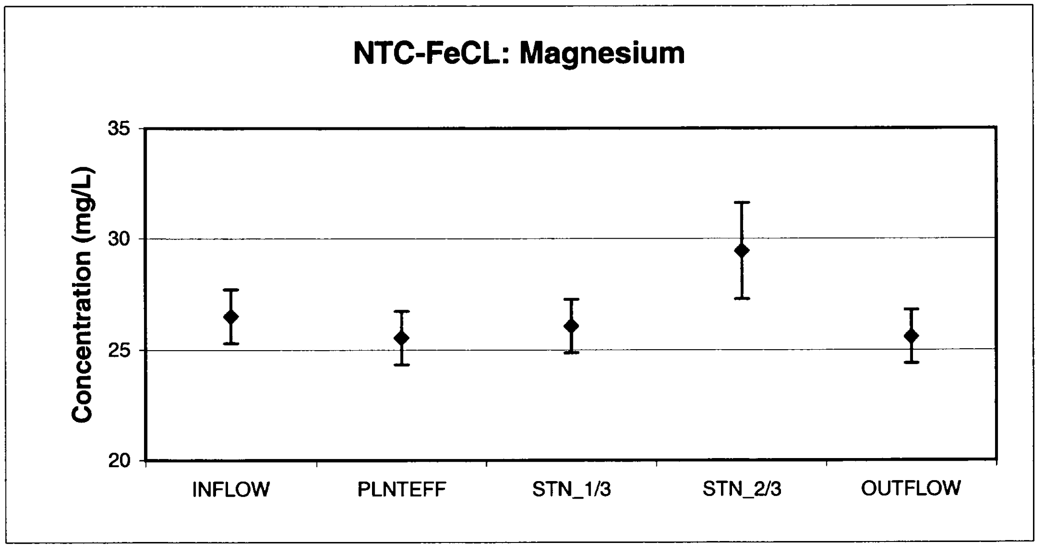
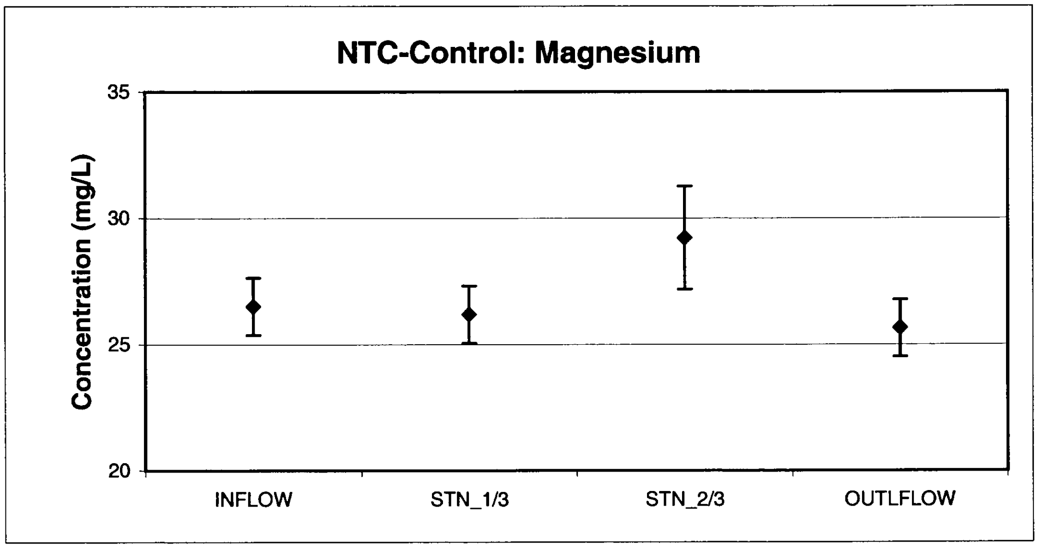


Exhibit 5-56
STC standard error plots of iron for treatment period.





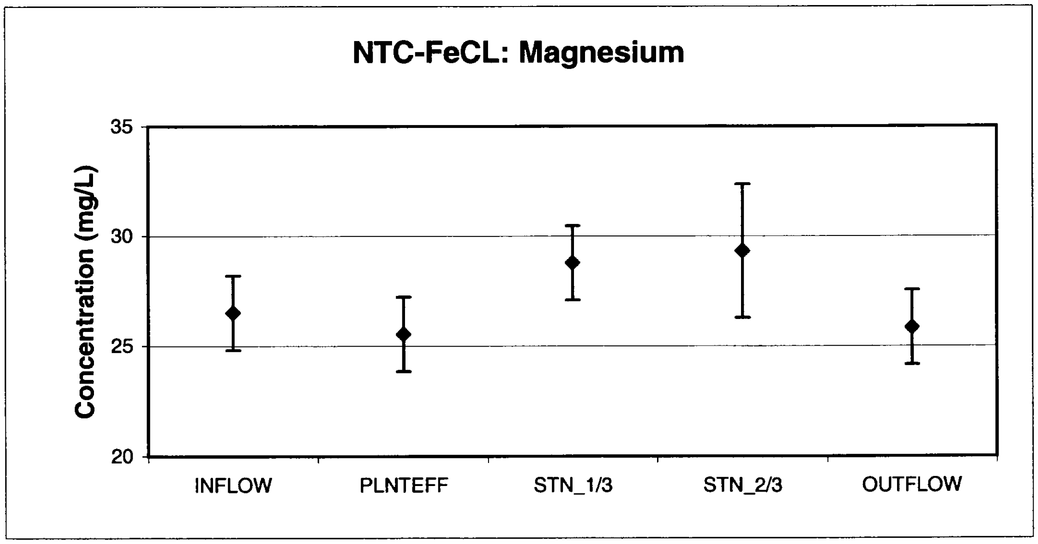
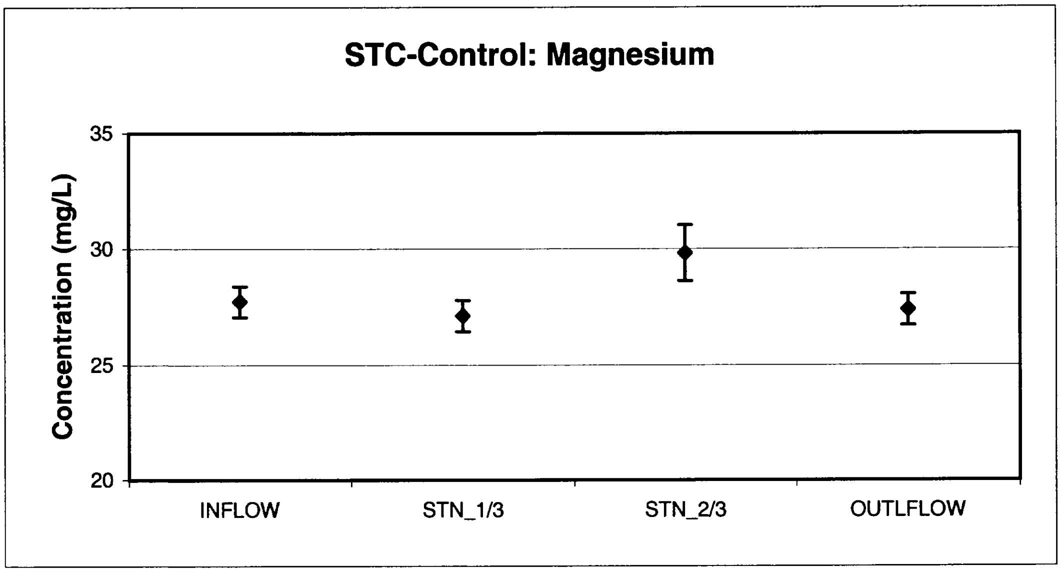


Exhibit 5-57
NTC standard error plots for magnesium for treatment period.



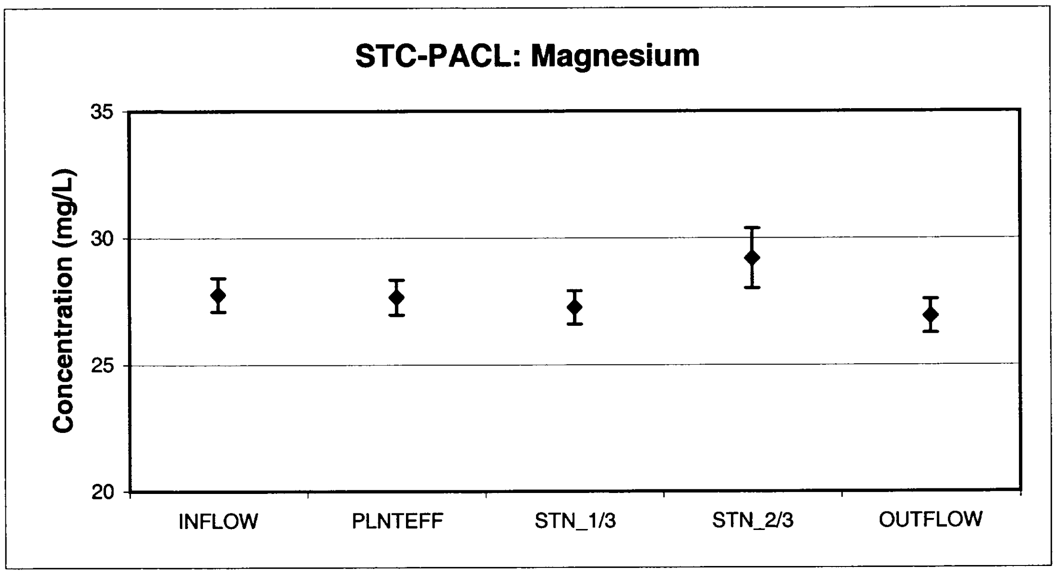
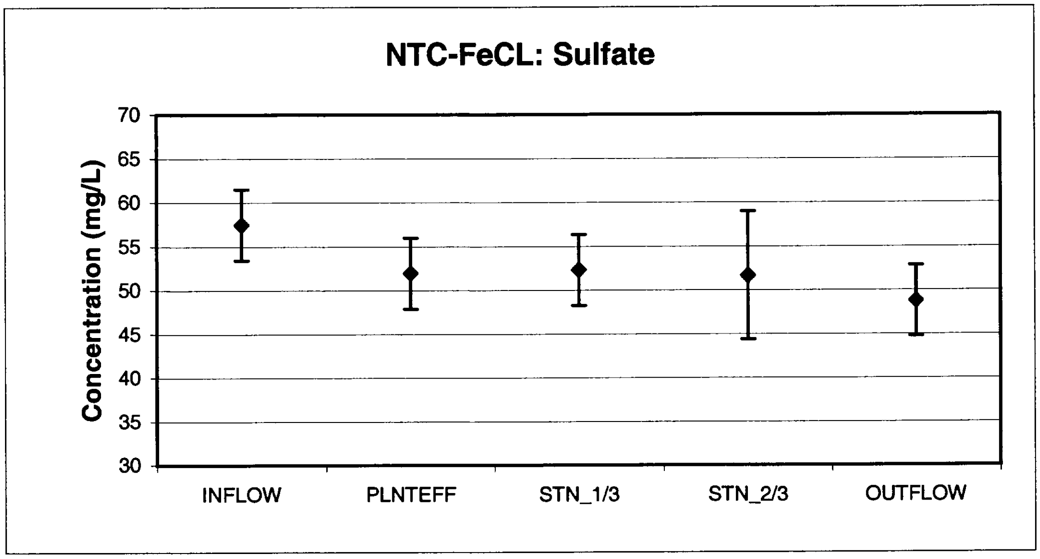
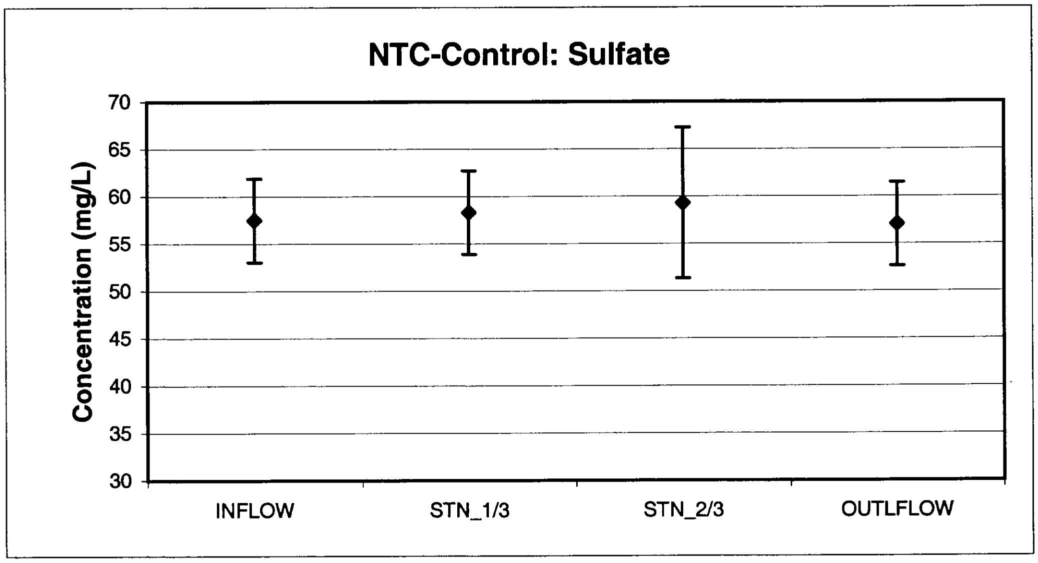


Exhibit 5-58
STC standard error plots for magnesium for treatment period.





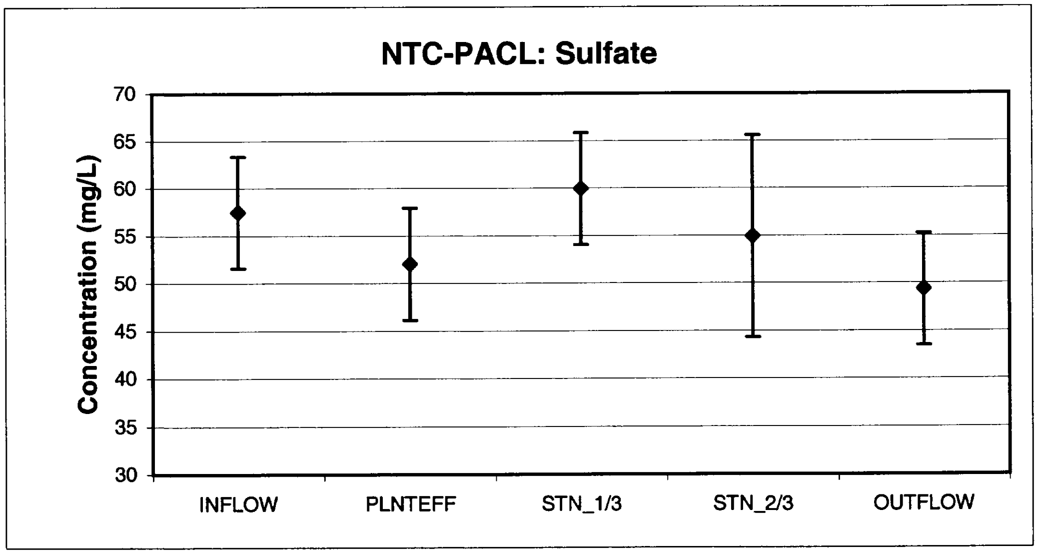
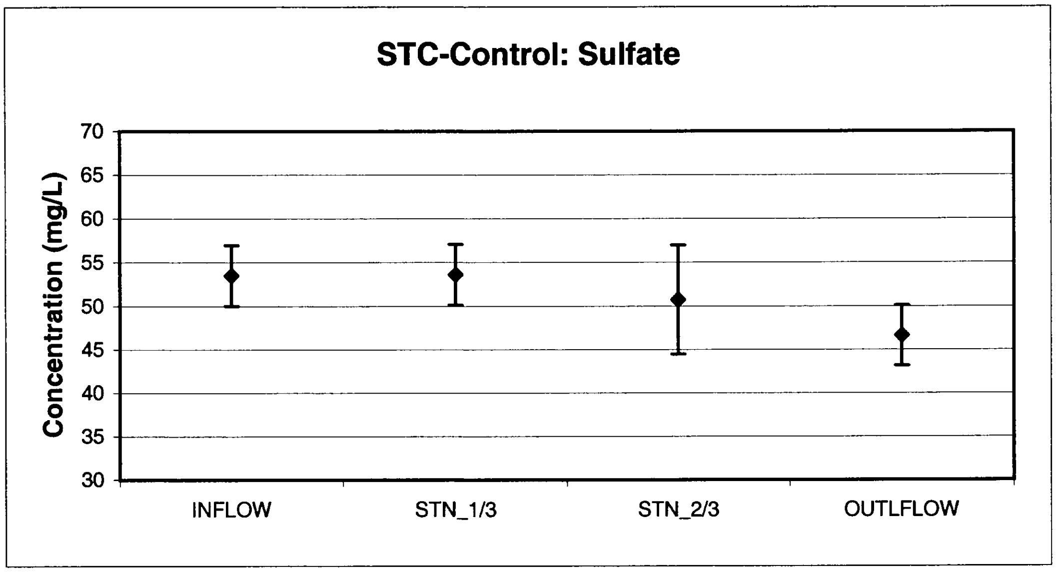


Exhibit 5-59
NTC standard error plots for sulfate for treatment period.



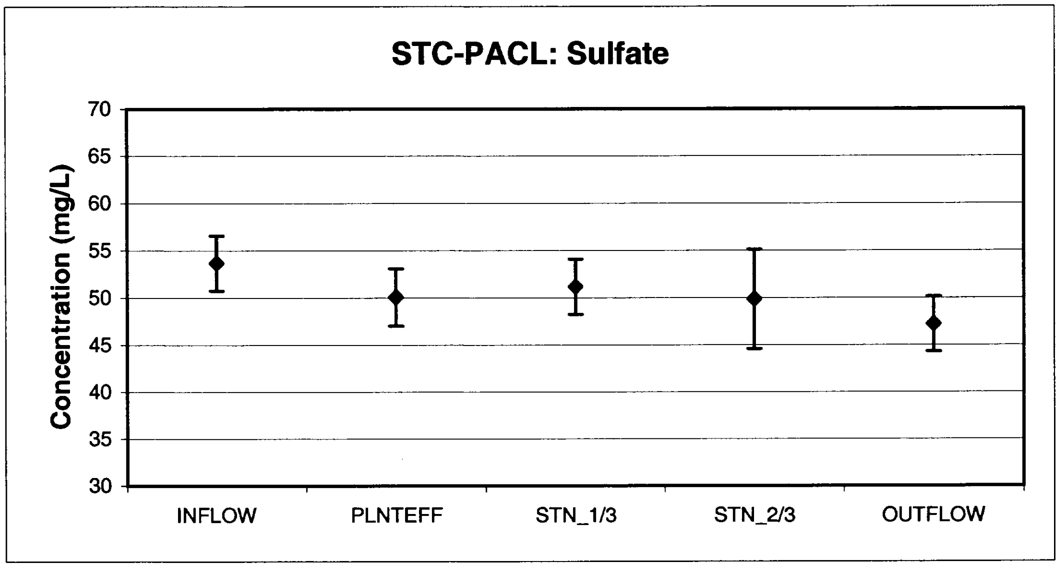
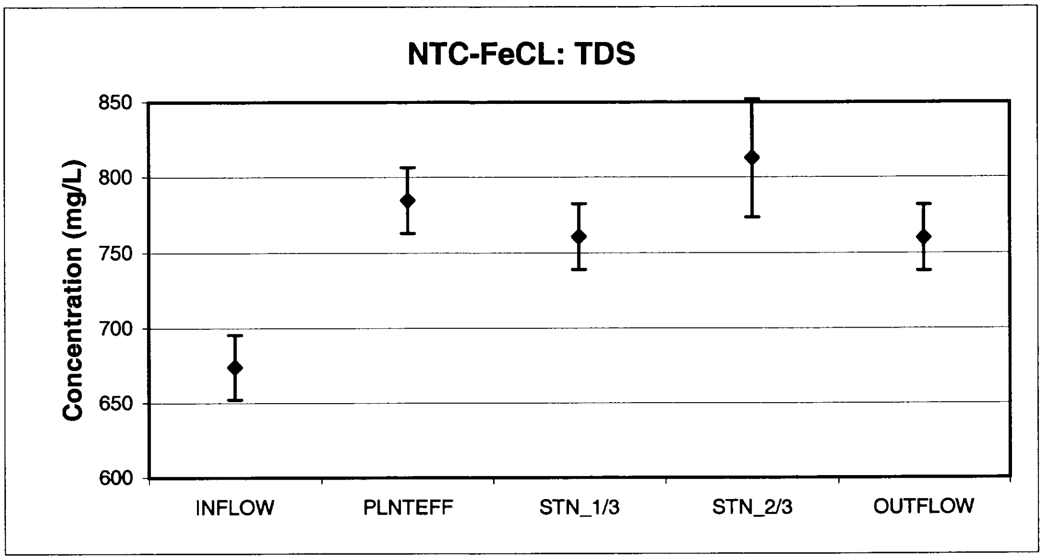
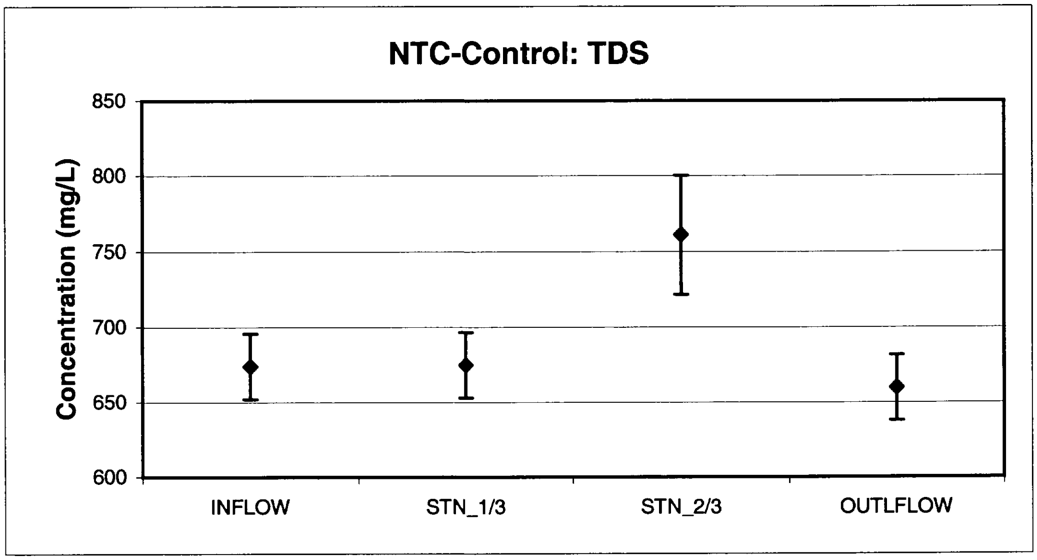


Exhibit 5-60
STC standard error plots for sulfate for treatment period.





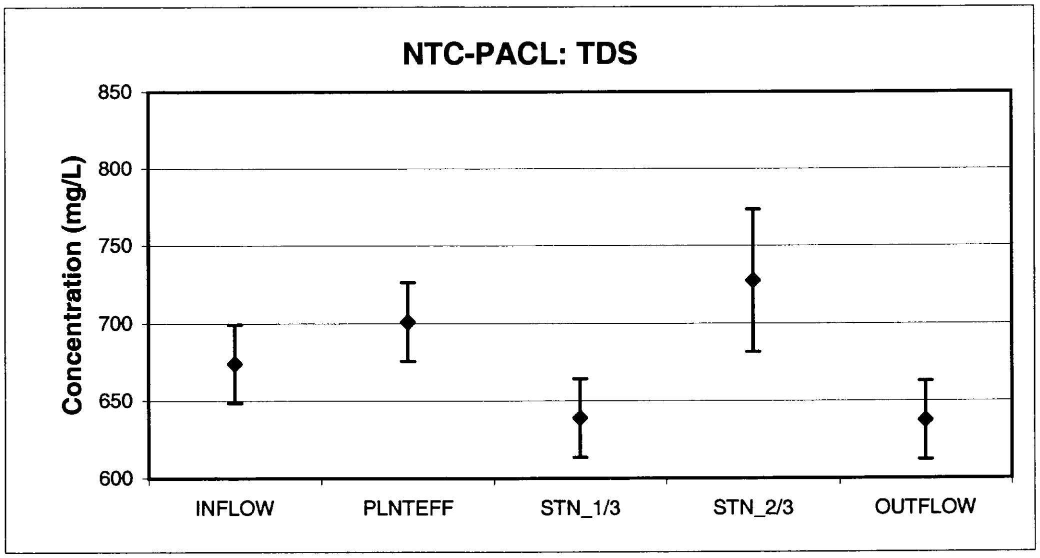
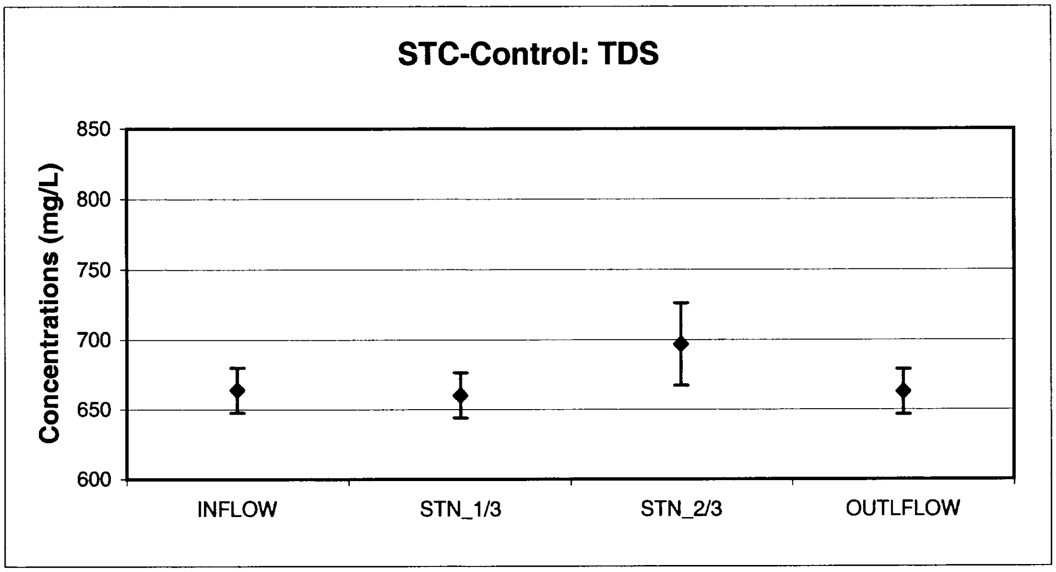


Exhibit 5-61
NTC standard error plots for TDS for treatment period.



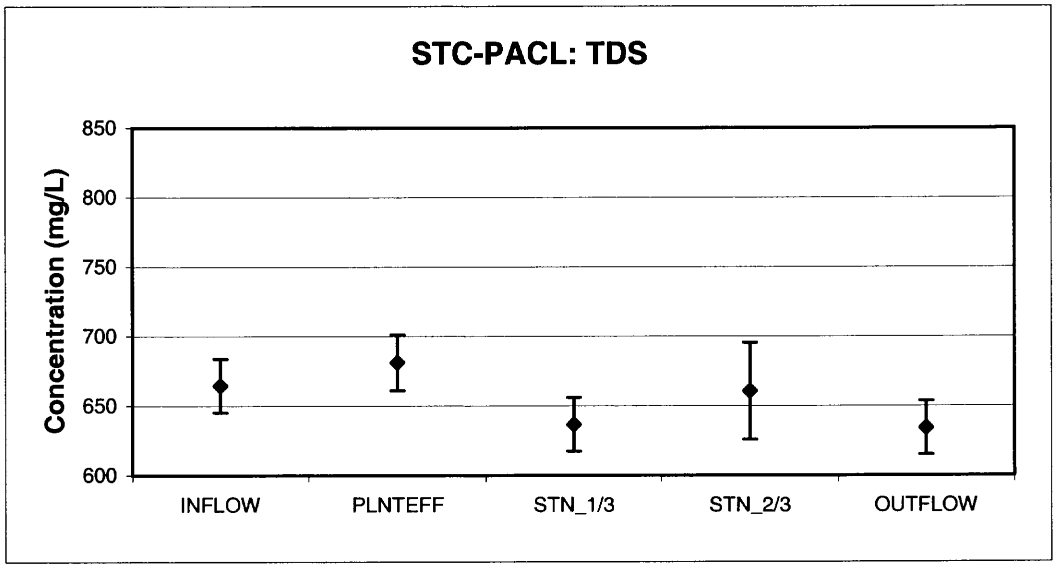
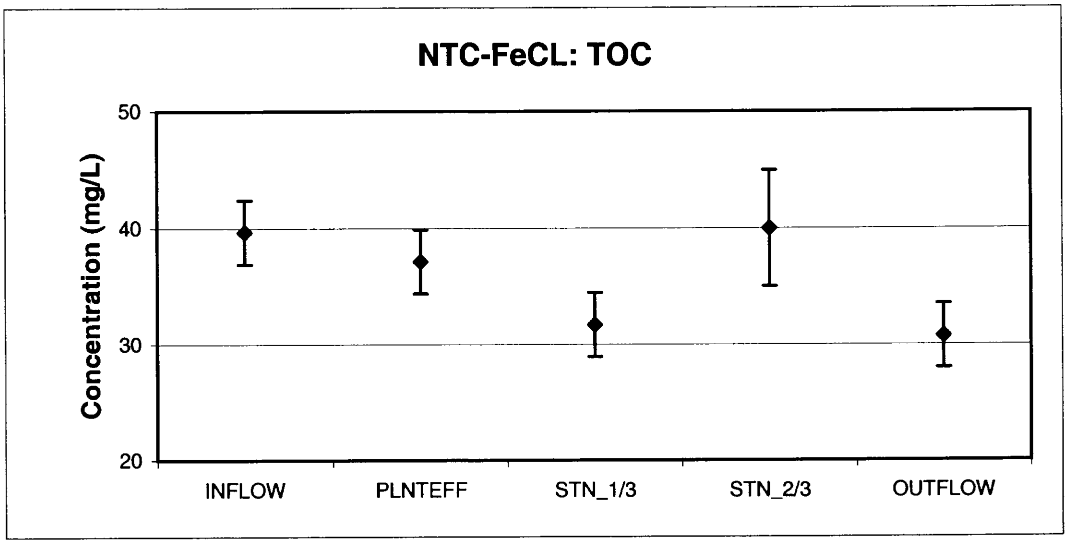
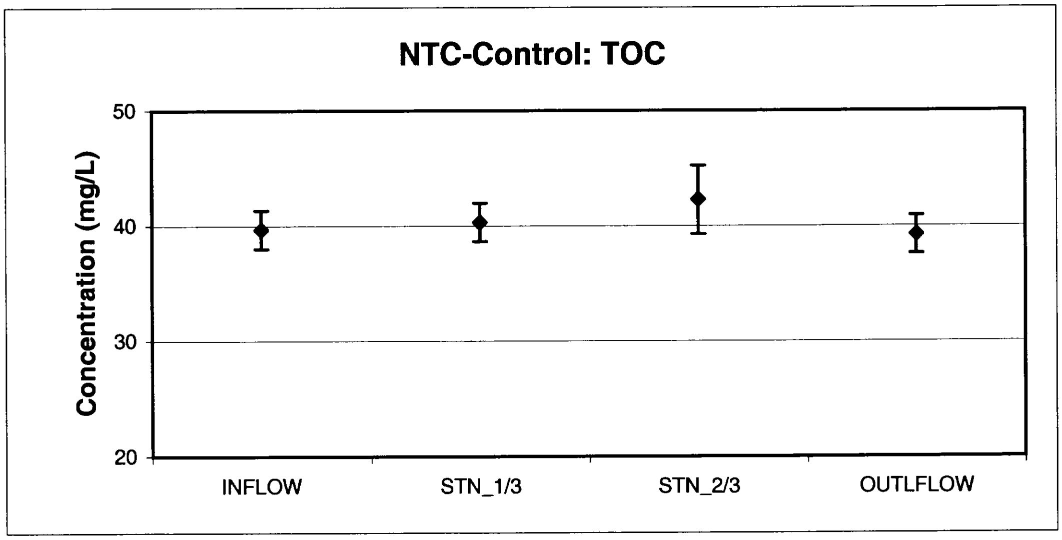


Exhibit 5-62
STC standard error plots for TDS for treatment period.





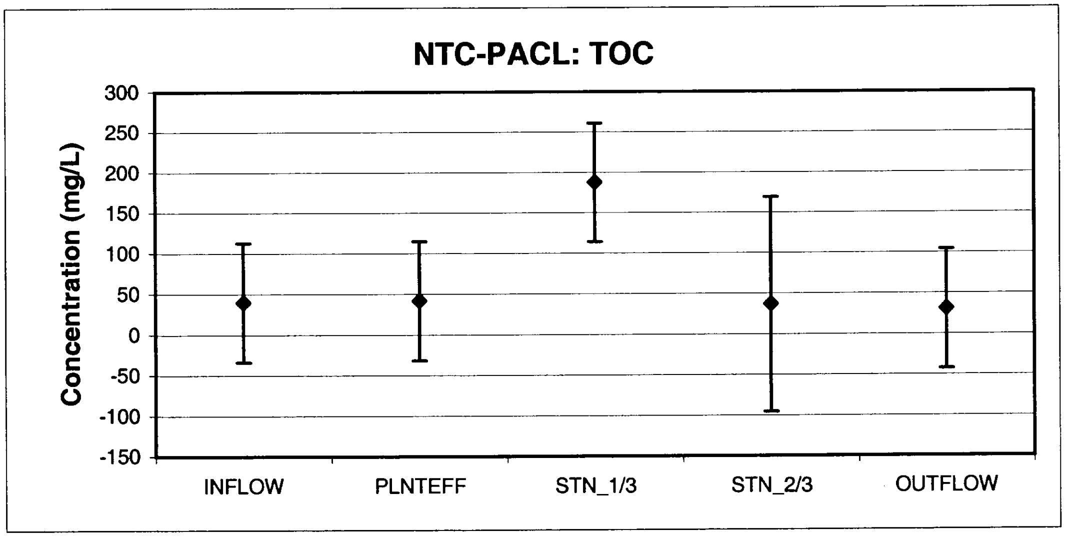
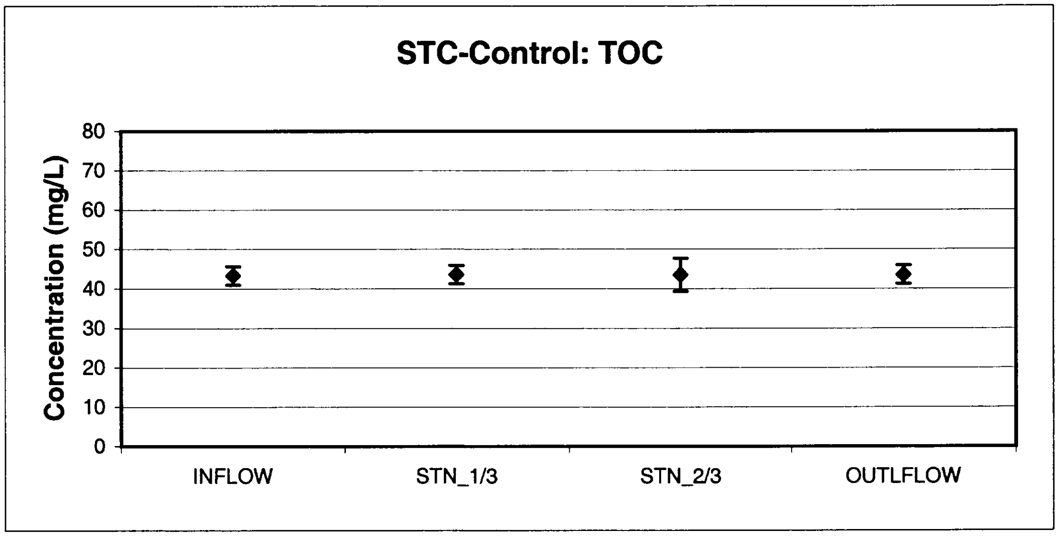


Exhibit 5-63
NTC standard error plots for TOC for treatment period.



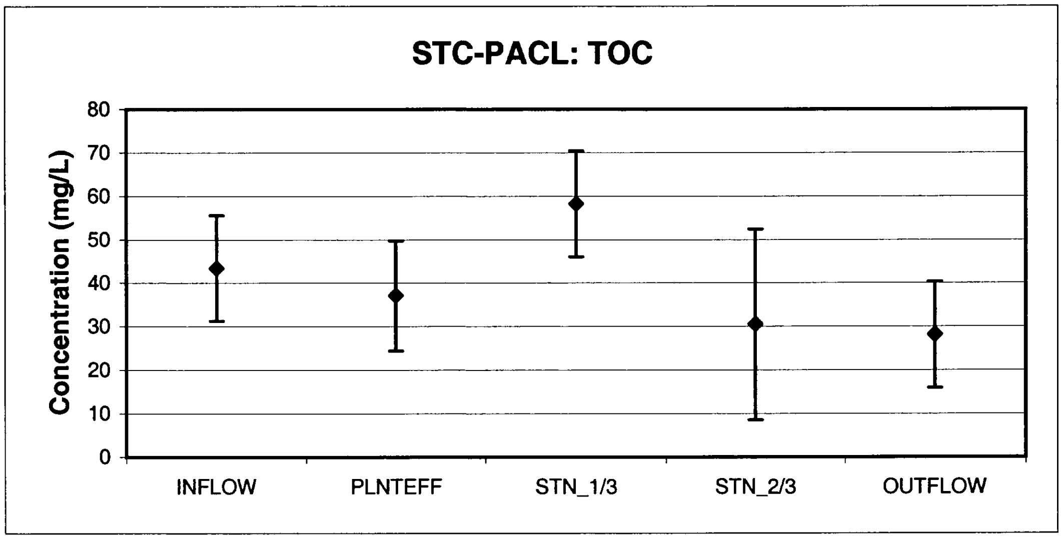
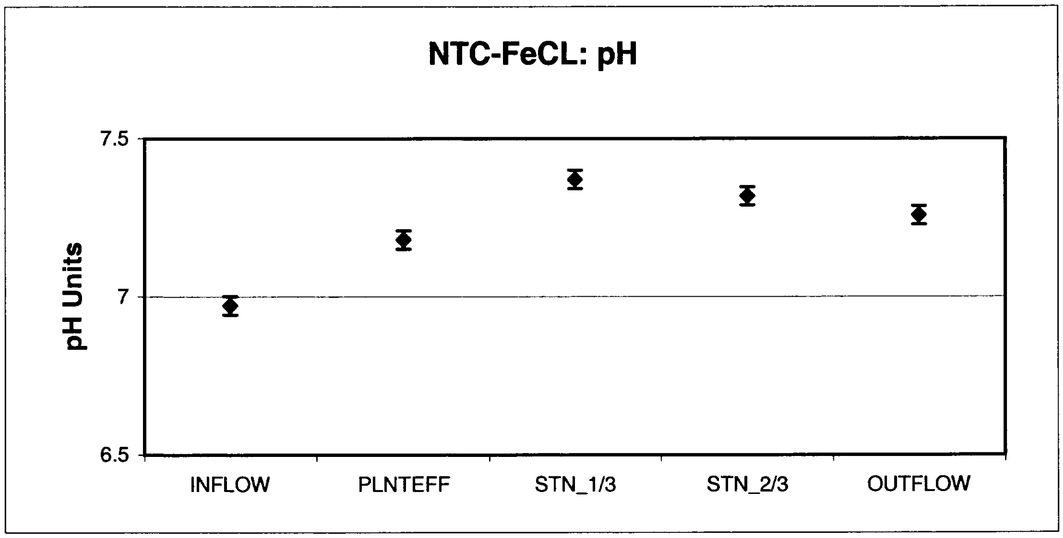
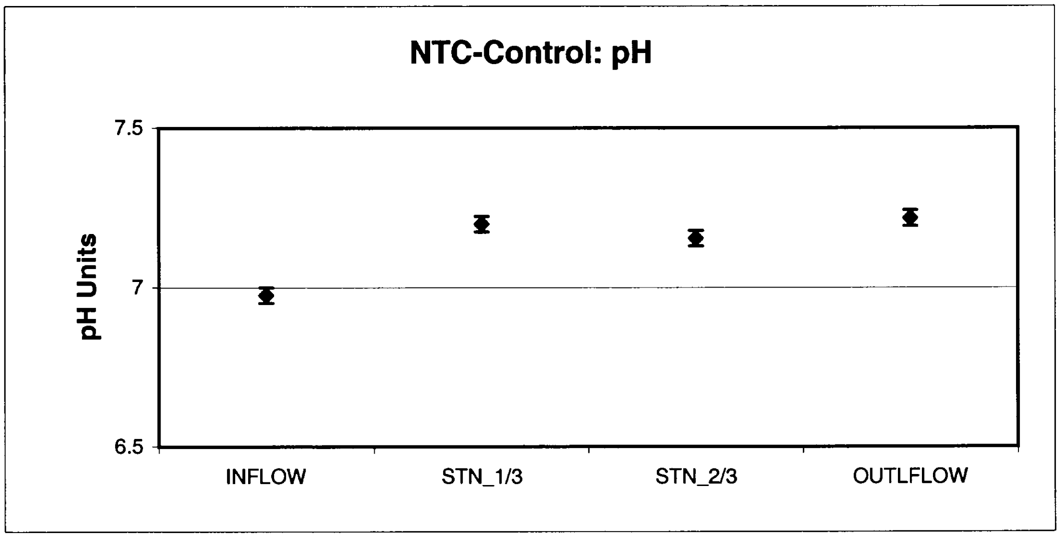


Exhibit 5-64
STC standard error plots for TOC for treatment period.





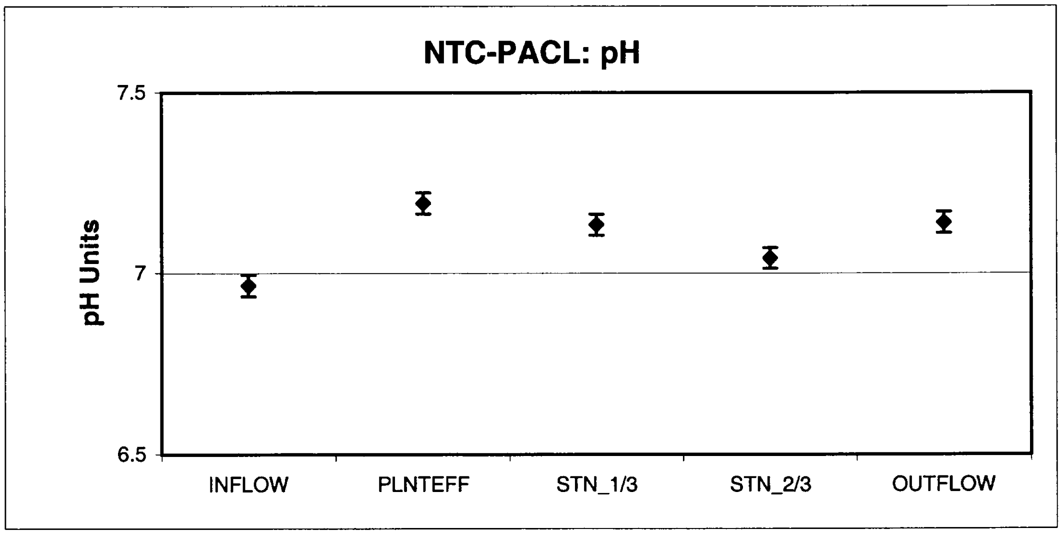
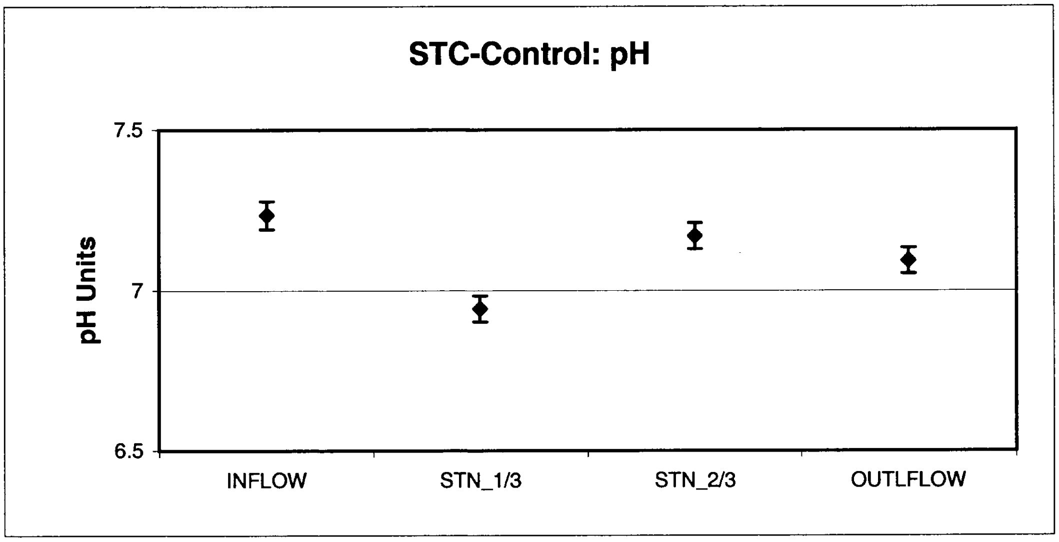


Exhibit 5-65
NTC standard error plots of pH during the treatment period.



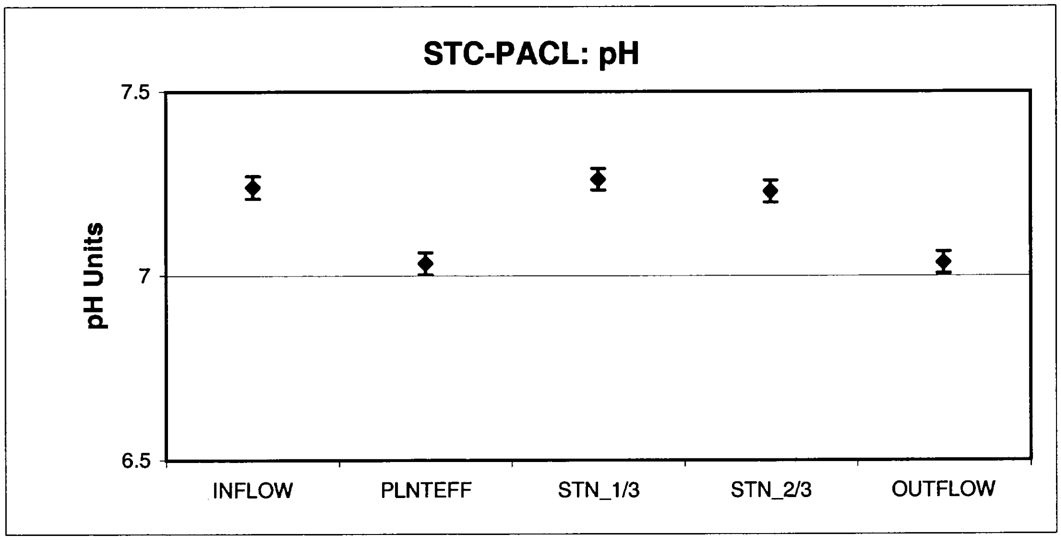
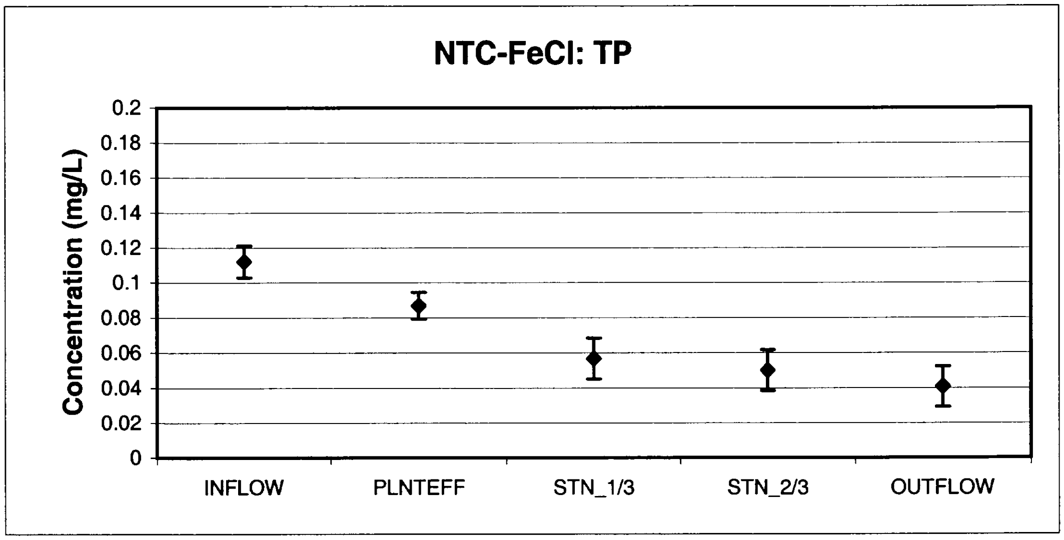
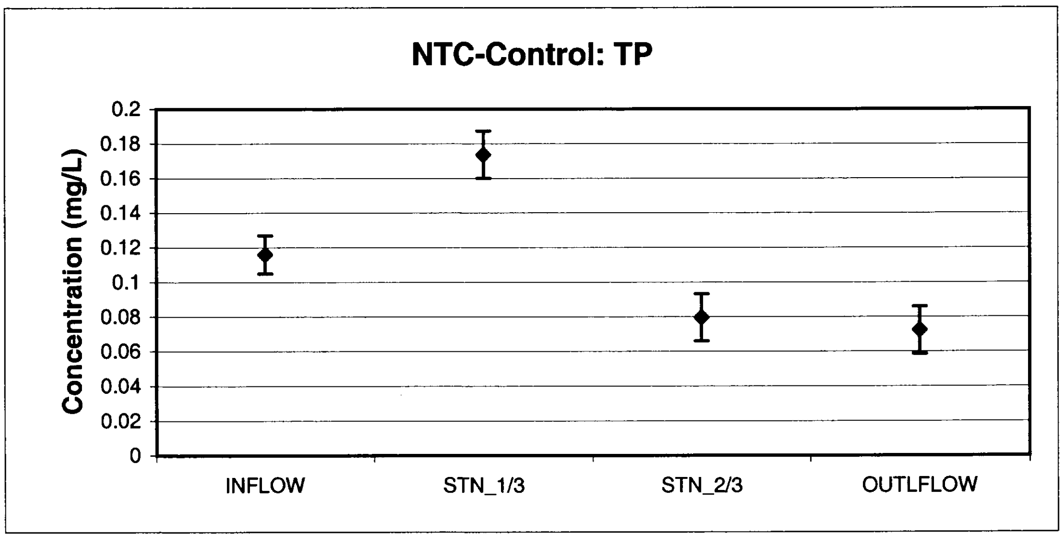


Exhibit 5-66
STC standard error plots of pH during the treatment period.





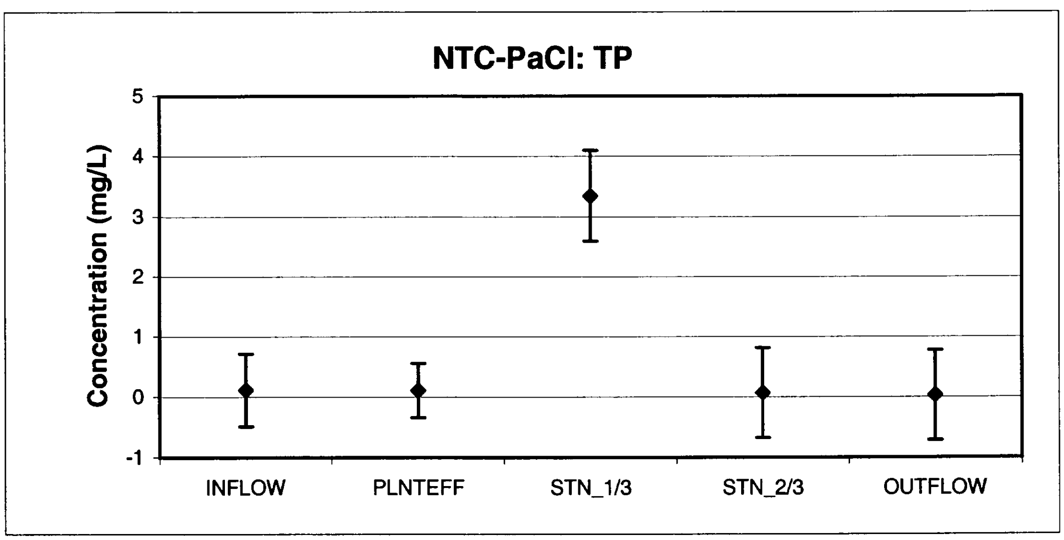
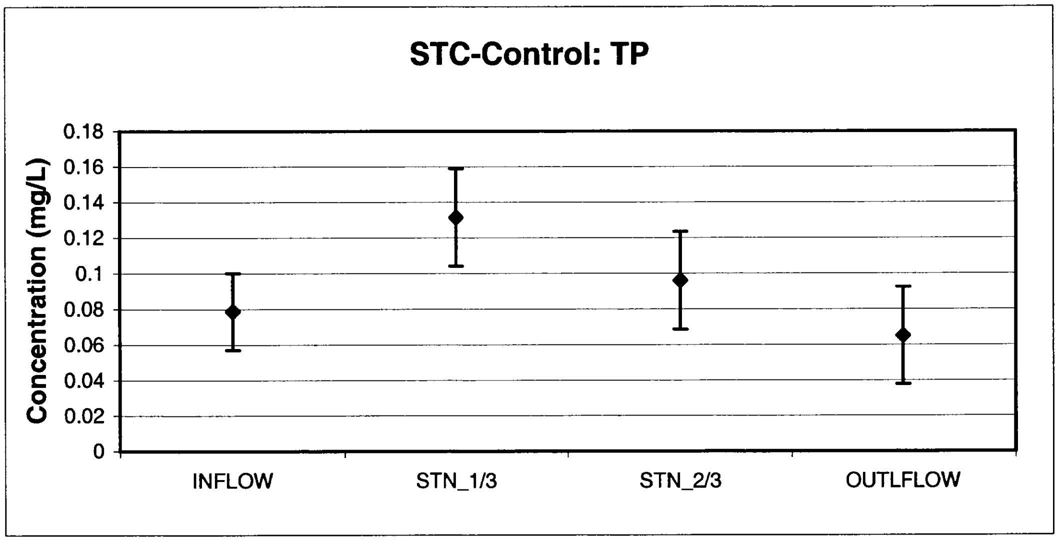


Exhibit 5-67
NTC standard error plot for total phosphorus for treatment period.



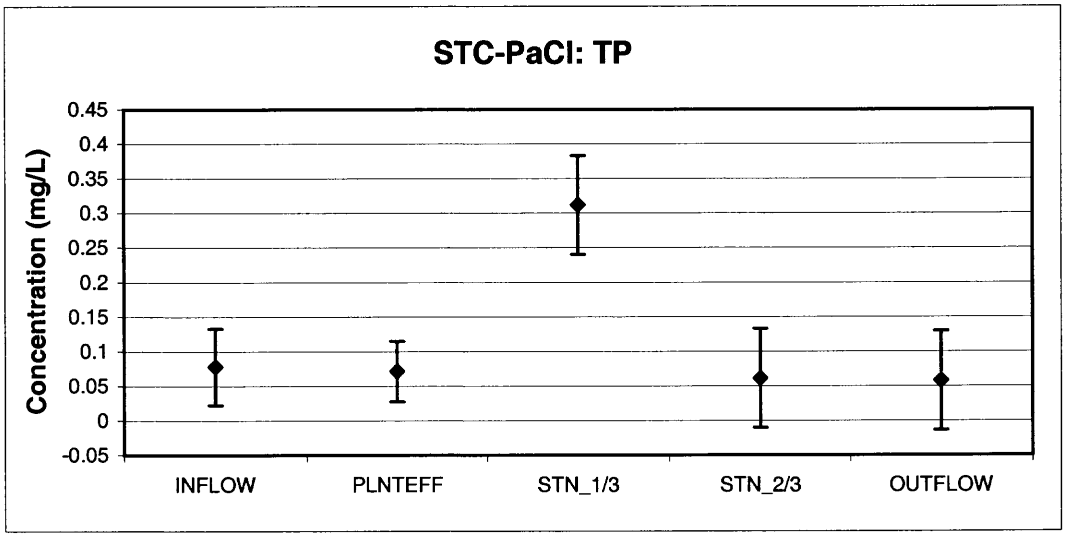
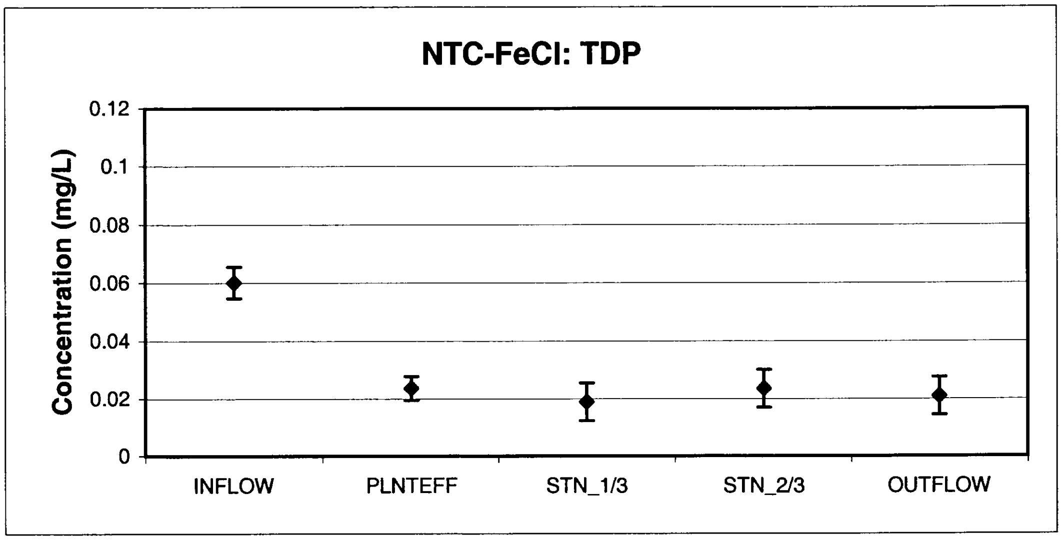
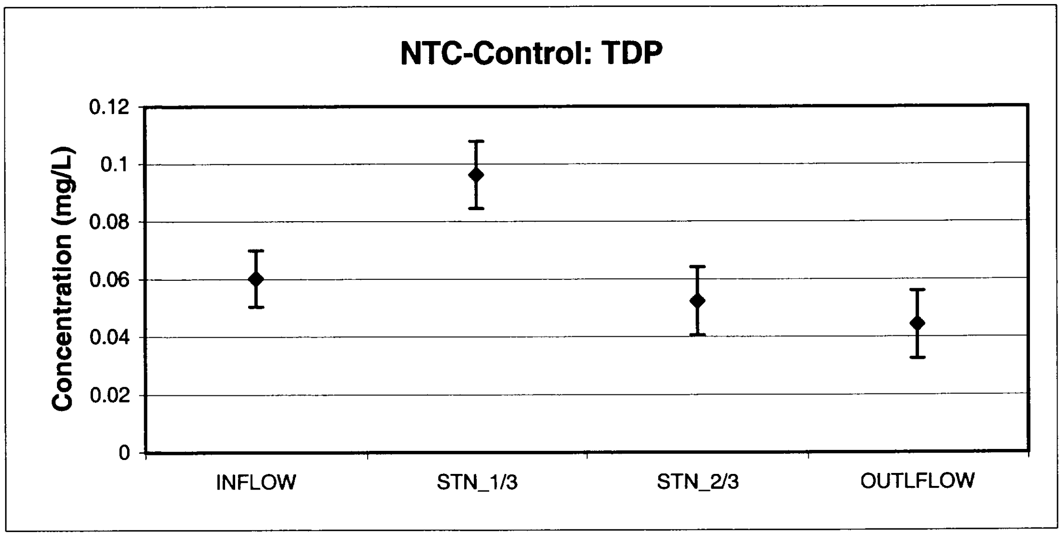


Exhibit 5-68
STC standard error plot for total phosphorus for treatment period.





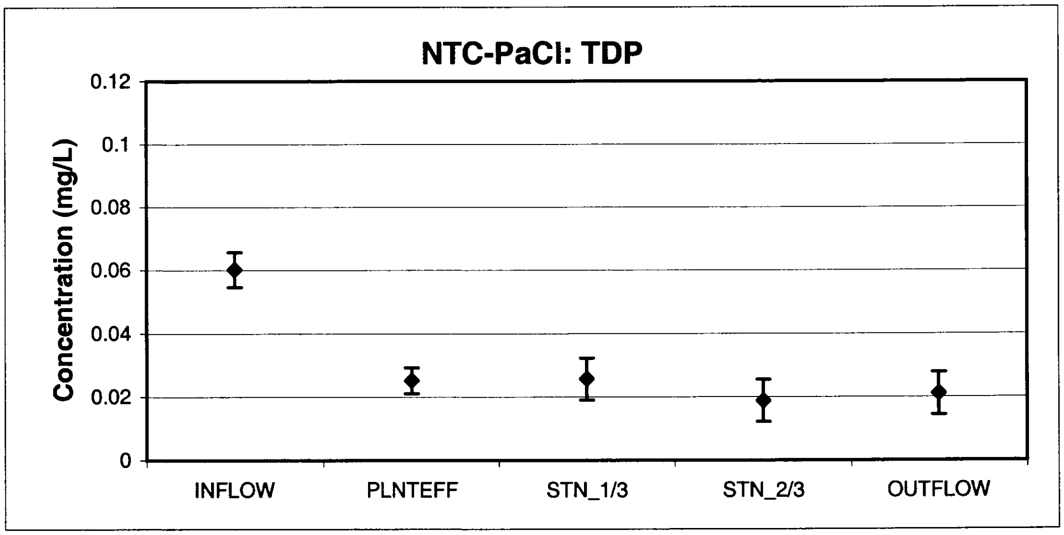
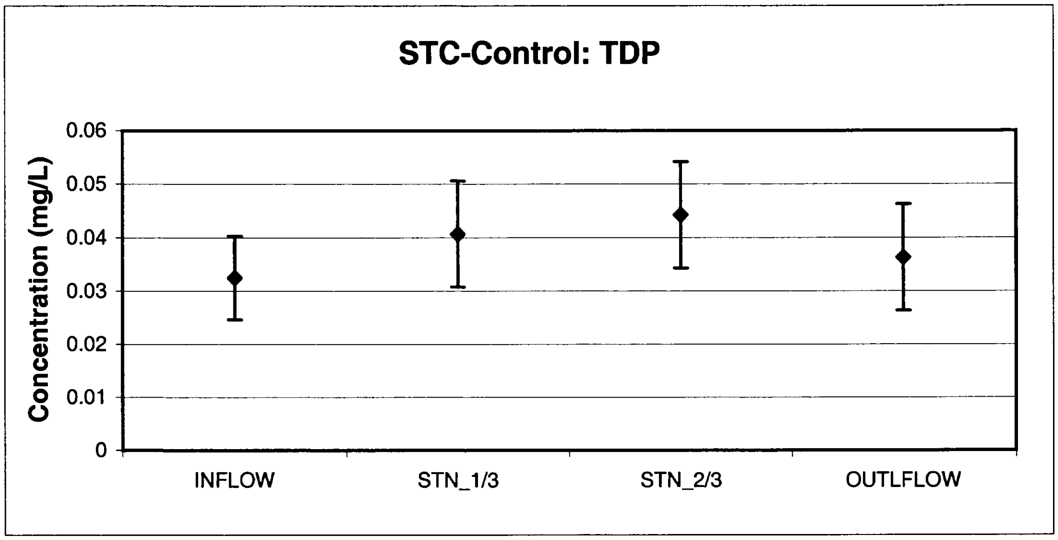


Exhibit 5-69
NTC standard error plot for total dissolved phosphorus for treatment period.



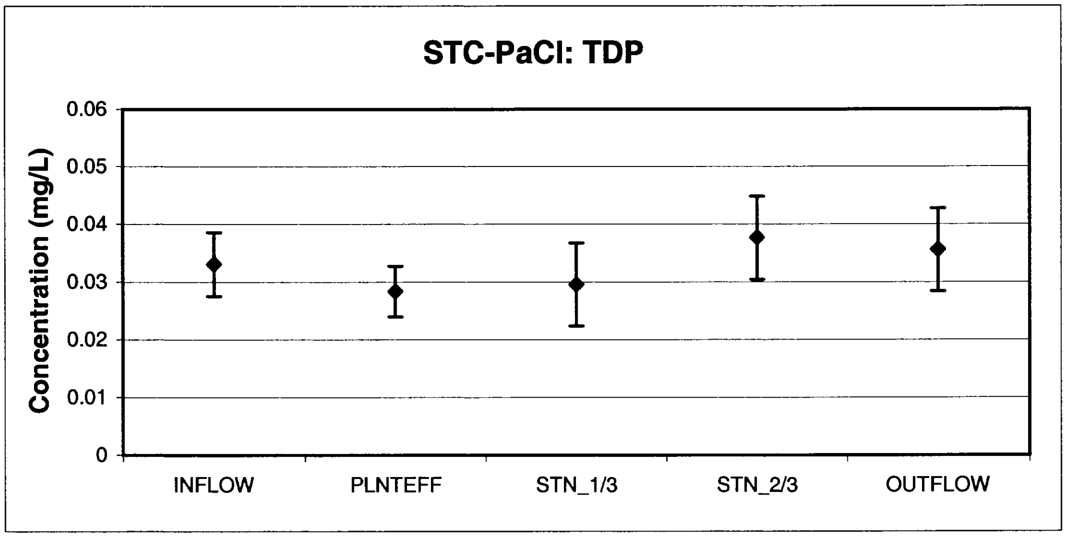
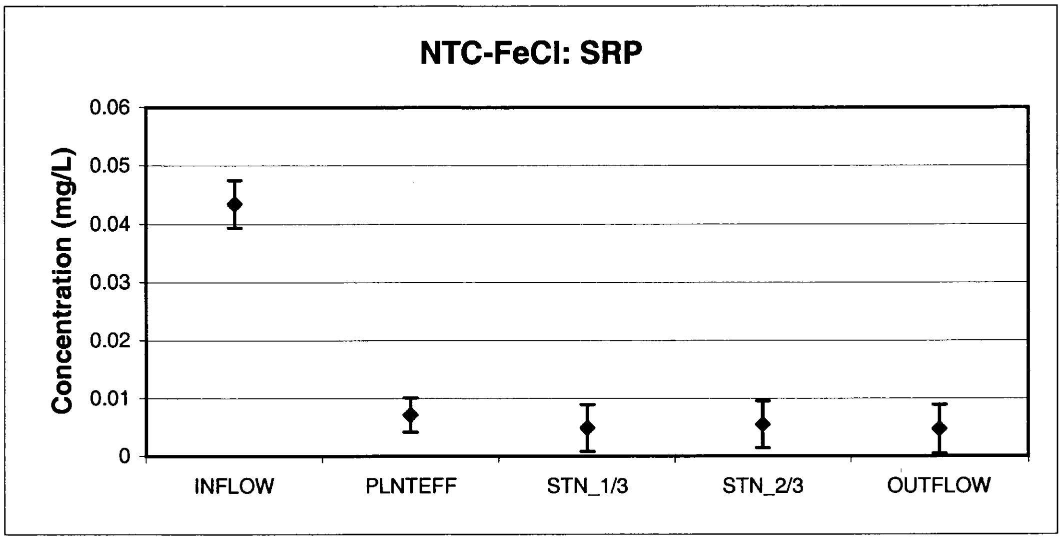
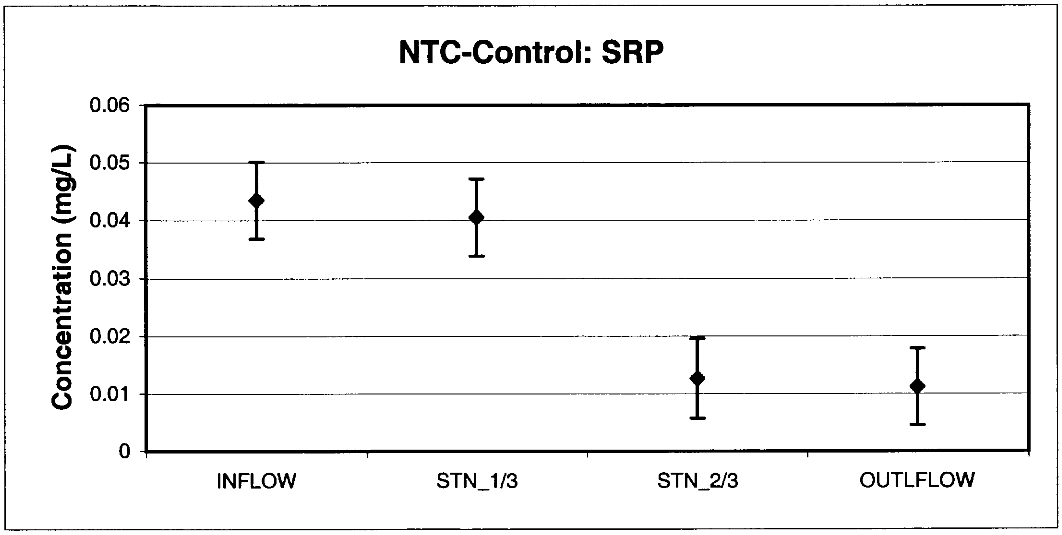


Exhibit 5-70
STC standard error plot for total dissolved phosphorus for treatment period.





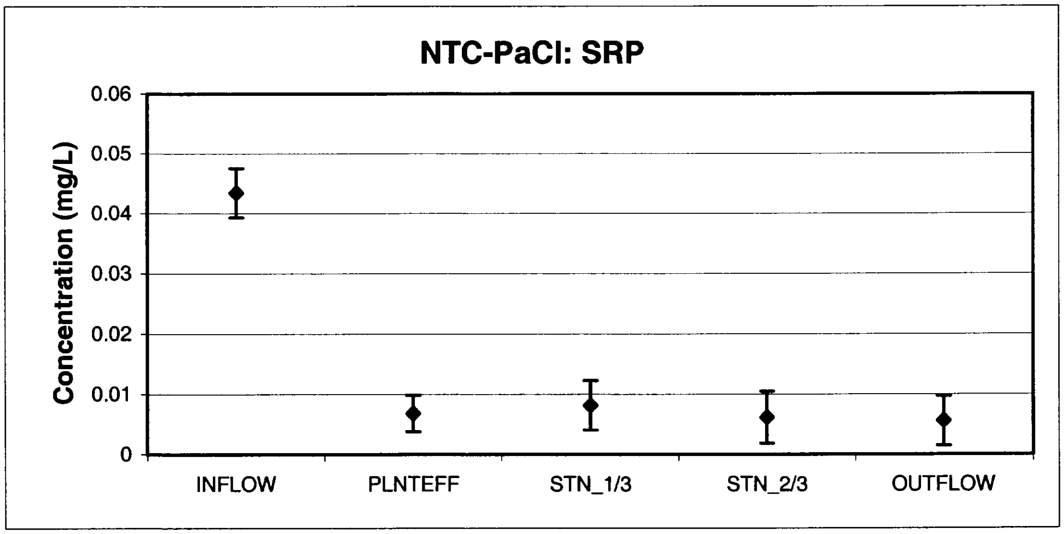
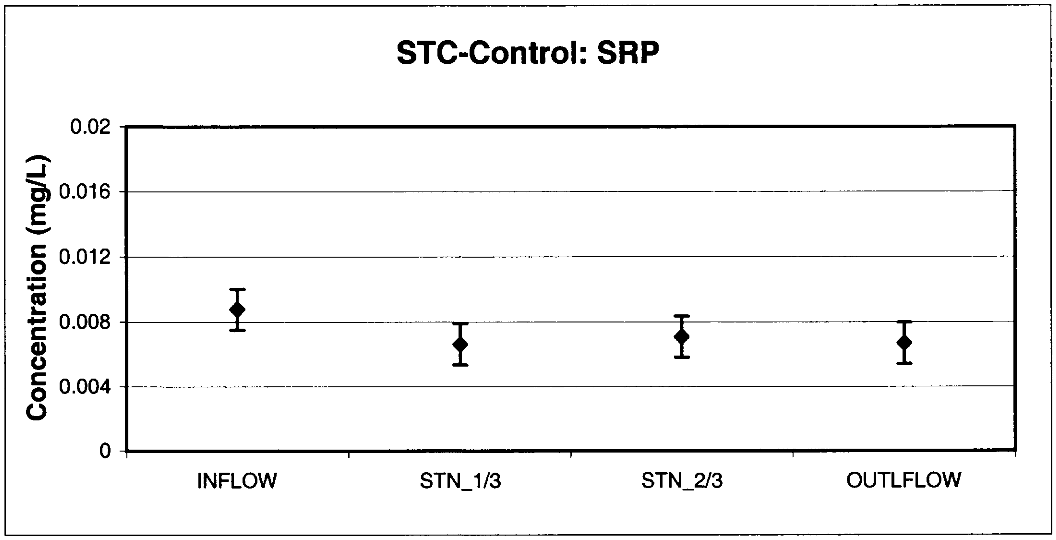


Exhibit 5-71
NTC standard error plot for soluble reactive phosphorus for treatment period.



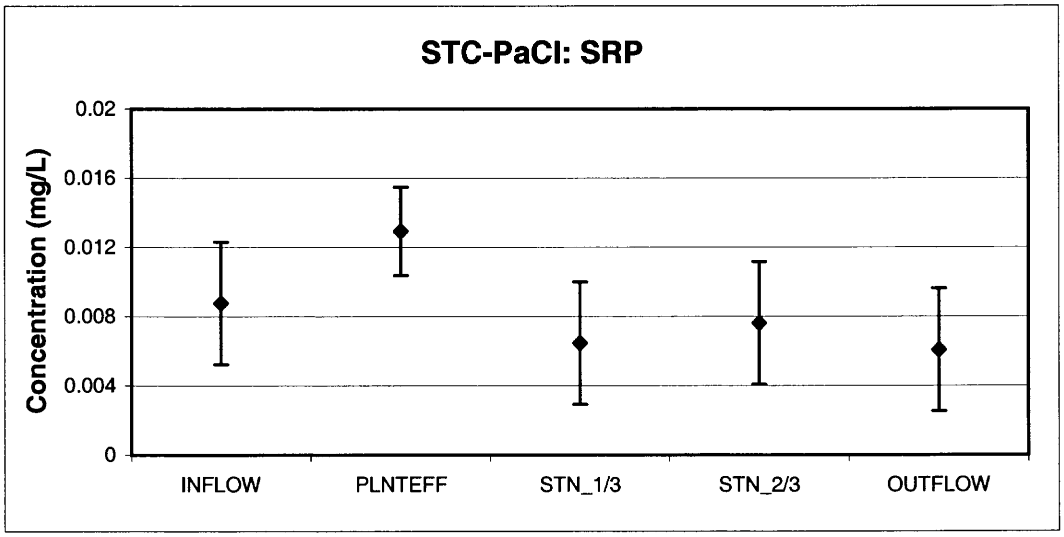
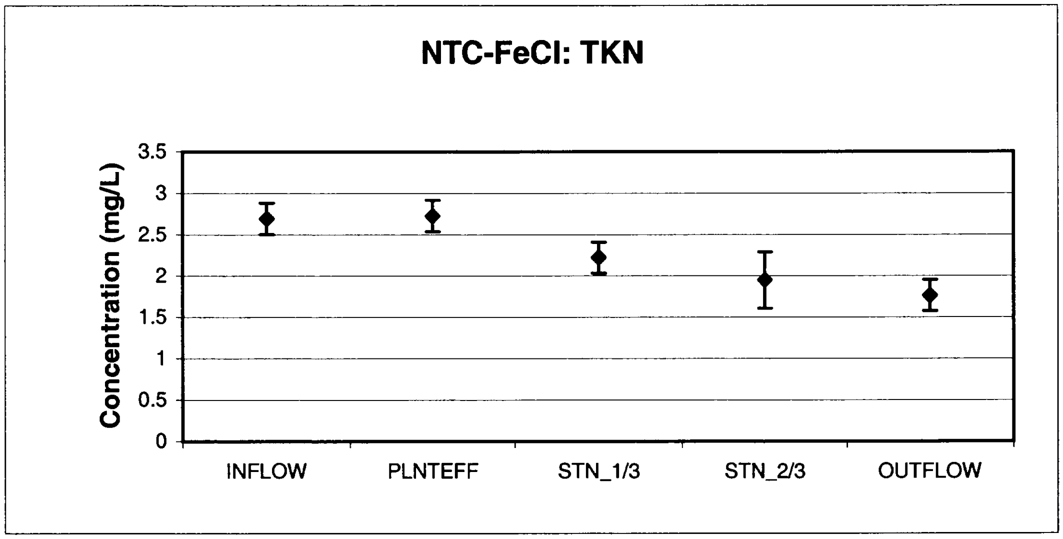
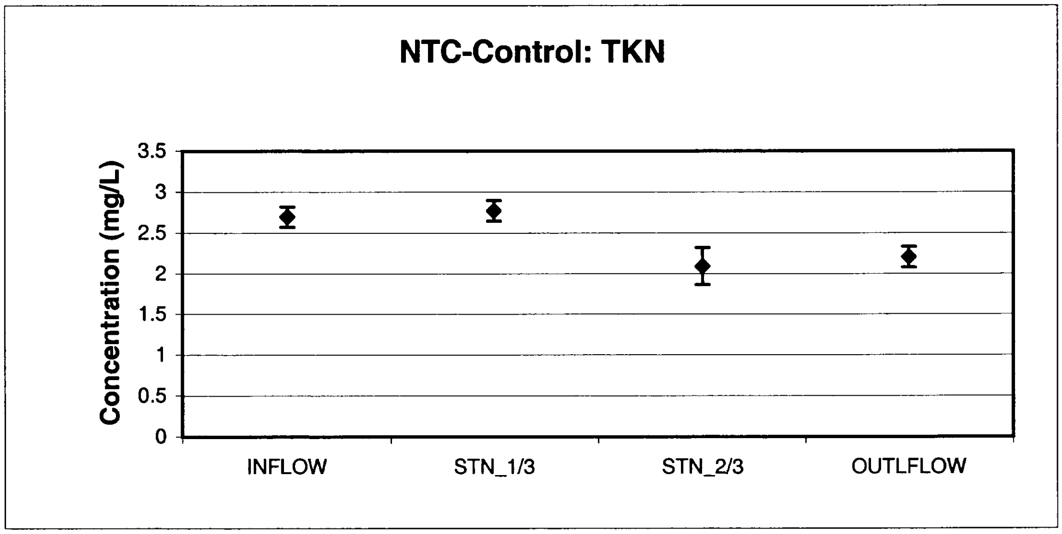


Exhibit 5-72
STC standard error plot for soluble reactive phosphorus for treatment period.





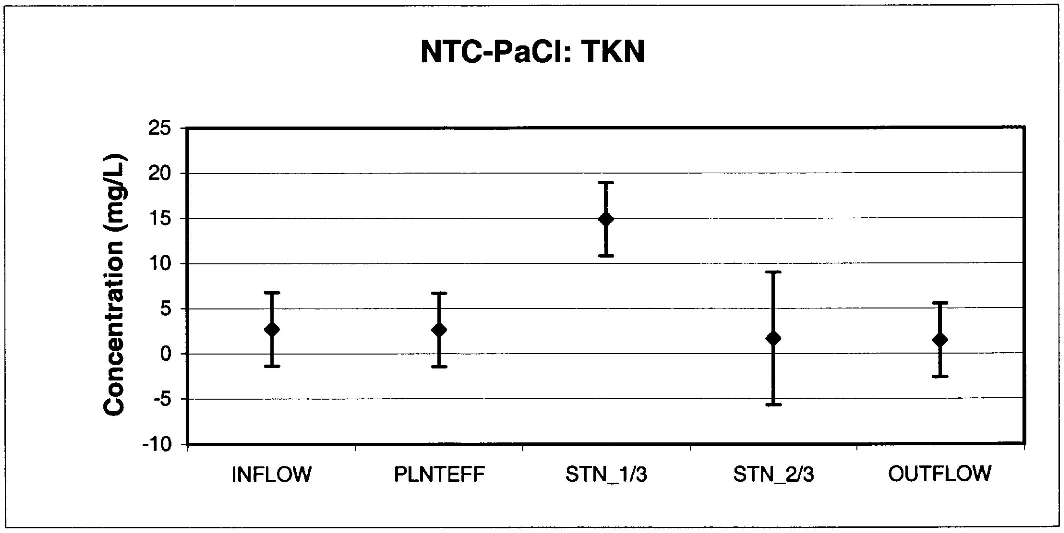
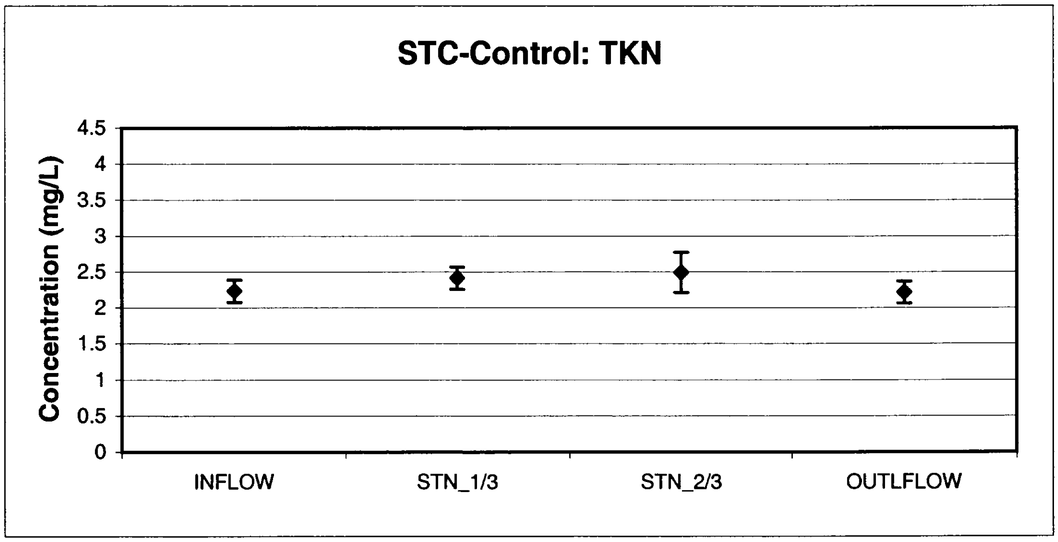


Exhibit 5-73
NTC standard error plot for TKN for treatment period.



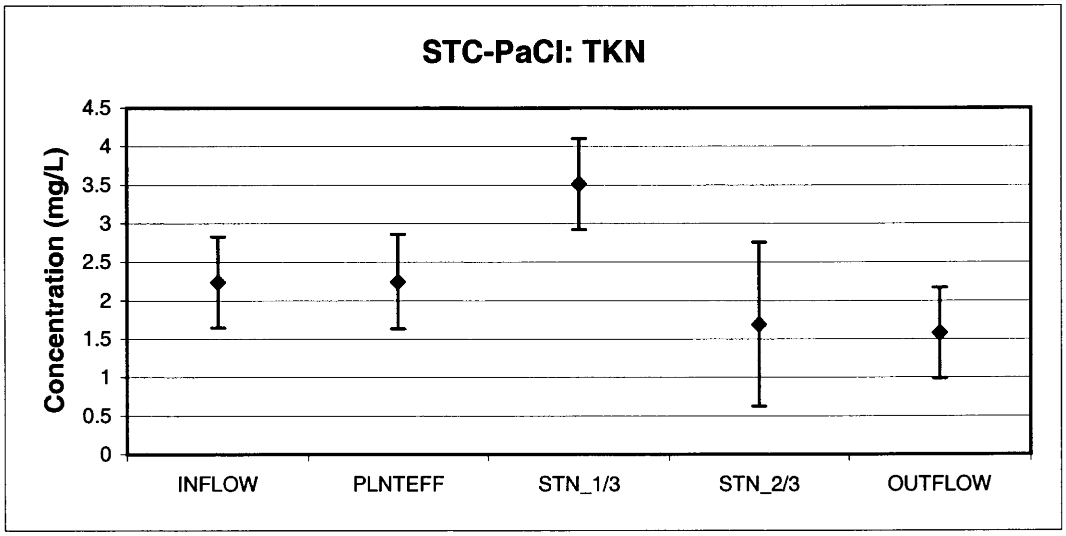


Exhibit 5-74
NTC standard error plot for TKN for treatment period.